IN-0464-08



# PRELIMINARY ENGINEERING STUDY ON THE MASS FINISHING WASTES AT BREMEN BEARING, INC. BREMEN, INDIANA

DECEMBER 14, 1984

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### SUMMARY

This report summarizes the findings of an engineering study into the characteristics of the mass finishing wastestreams at Bremen Bearing Corporation, Bremen, Indiana. The study has determined that closure of the existing settling ponds and replacement with a package filtration system employing water reuse is technically feasible. The estimated probable cost for the construction of the proposed treatment system is about $180,000.

### CONCLUSIONS

Based upon the results of laboratory testing, an evaluation of the existing plant operation, treatability tests and on an evaluation of available treatment alternatives, the following conclusions are made:

1. The particle size and density of the suspended solids from Bremen Bearing wastestreams makes them conducive to vacuum filtration.

2. The wastestreams contain resources of oil, iron, chromium, and water that if recovered or reused could provide substantial cost savings to Bremen Bearing Corporation.

3. The grinding solids are of sufficient size, quality and density to allow for filtration without a filter aid and without biological decomposition that might produce odors.

4. Contaminants other than solids pose no major problem for discharge to the Town sewer since heavy metals will be filtered out with the solids.

### RECOMMENDATIONS

Based upon the findings of this study, the following recommendations are made:

1. Construct a treatment system to replace the settling ponds. The system would consist of oil separation and reclamation, flow equalization, magnetic separation of steel fines for recovery, flat bed vacuum filtration for solids removal and disposal to a landfill, and clarified water reuse.

2. Conduct a market survey for the sale of reclaimed oil, chromium fines, and steel fines with the determination of specific buyers prior to proceeding to final design stage.

3. Contingent upon the findings of a buyer for the chromium fines, investigate through a detailed pilot study the feasible methods for chromium recovery and its conversion to a marketable product.

4. Prepare final design plans, specifications and permit applications for construction of the proposed treatment system.

# 1. INTRODUCTION

## 1.1 AUTHORITY FOR REPORT

This report is compiled in accordance with agreement for engineering services between Bremen Bearing Corporation, Bremen, Indiana and Clyde E. Williams and Associates by Purchase Order 45506 dated September 27, 1984

## 1.2 PURPOSE

The purpose of the Study was to provide conceptual preliminary engineering and determine the optimum method of wastewater treatment and sludge disposal.

## 1.3 SCOPE

The Study was to encompass the following tasks:

1. Identification of waste water sources, flow rates, and quality.

2. Mass balance of water sources vs. discharges.

3. Site survey to evaluate directing discharge to two lagoons into a single system.

4. Treatability study, including settling tests, particle size determination, specific gravity tests, filter leaf tests.

5. Investigation of possible recovery and reuse of waste water.

6. Investigation of possible recovery and sale of waste residues.

## 1.4 PROBLEM DEFINITION

At Bremen Bearing there are four main process wastestreams entering the existing surface impoundments. These are:

1. Barrel and Vibratory Finishing (Liming Dept.)

2. Abrasive Knob Removal (Knobbing Dept.)

3. Green Tumbling

4. Heat Treat (Quench Bath)

## 2. PROCESS DESCRIPTION AND WASTESTREAM SOURCES

Mass finishing, commonly called tumbling or vibratory finishing is a precision controlled method of processing small or large quantities of parts to improve surface finishes, remove burrs, sharp edges, tool marks, flash, heat treat scale, and to form radii. Any metal and metal alloy as well as many plastic rubber and ceramic parts which can be physically accommodated in the machine equipment, may be processed. In mass finishing, parts are processed in machines which impart either a revolving or vibratory type motion between the parts and the media. The media (natural or synthetic) passes across the surfaces of the work pieces with sufficient impact and sliding action to produce parts with surfaces refined to specific job requirements. The essential components involved in the process are:

1. Machine equipment
2. Media
3. Compounds
4. Water levels
5. Time cycles

The media used in mass finishing applications to deburr, refine or polish parts are 1) manufactured abrasive and metallic products, 2) natural stone and agricultural materials. Aluminum oxide, the most popular type media in use today because of its abrading and color-imparting qualities is used at Bremen Bearing. Agricultural products, such as ground corn cob and walnut shells, are used for light deburring and polishing operations. Another media used at Bremen Bearing is limestone, which has a higher rate of wear than other natural stones is used for cutting and finishing, particularly where smooth finishes are required.

In addition to the media used in the tumbling operation, various compounds are added to the process to control stock removal, deburring, scale removal, cleaning, polishing, and burnishing of parts. Compounds provide lubrication, water softening, keep parts and abrasive media clean, prevent abrasive from loading or glazing, and develop color or luster on parts. For cut down operations, a non-lubricant compound may be used; for finishing operations, lubricant compounds are used. Compounds may be acid, alkali or neutral, according to the finishing requirements. In addition, to these three basic compounds, there are also cutting compounds, consisting of fine grit abrasive, 80 grit and finer, in combination with chemical agents. These compounds are usually powered materials that are added to the mass to produce abrasive, cleaning or polishing action. They may contain various types of abrasives, detergents, rust inhibitors, high titer soaps, alkali cleaners, acidic salts, synthetic detergents, water softening agents or buffering agents. Rust preventative agents are added or included with the compound to prevent rusting or pitting. These types of protective oils protect parts from corrosion by forming a thin protective film.

These compounds are used in combination with water rinsing of the loads. Thorough rinsing of the machine, abrasive, and the work is essential when changing from one chemical to another, and to obtain a bright color finish. This is done by flushing all residual dirt and abrasive from the load and then adding fresh water.

Wastewater is generated by rinsing of the parts during and following the above tumbling operations. The wastewater can contain media, compounds, dilute oils, process chemicals, scale, abrasive grit, cleaners soaps, emulsified oils, steel fines, common metals such as chromium, or detergents. Area spills, cleaning and wash down produce wastes that enter wastewater streams.

Another process employed at Bremen Bearing generating a waste stream is the heat treating of metal in which the physical properties of a workpiece are modified to the desired properties through the application of controlled heating and cooling cycles. The workpiece after heating is cooled in the quench oil bath.

Quenching oils are of three general types: Conventional, fast, and water/oil emulsions (10-90% oil). A conventional oil contains no additives that will alter cooling characteristics. Fast quenching oils are blends which may contain specially developed proprietary additives such as nickel-zinc dithiophosphate. The wastes generated will contain the solution constituents as well as various scales, oxides and oils. Wastewater is generated through rinses, batch discharges (including batch dumps), spills and leaks. A large wastestream is generated from rinsing the heat treated parts following the oil quench.


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SITE LOCATION

BREMEN BEARING MASS FINISHING WASTES STUDY

ILLUSTRATION 2-1

## 3. WASTEWATER PRODUCTION RATE

### 3.1 WASTEWATER FLOW RATE

Bremen Bearing has kept monthly water use records of its overall water usage using a main plant meter (total) and a second meter which measures the flow to the knobbing department and heat treat operation. Illustration 3-1 shows the approximate locations of plant water piping. In order to arrive at design flow rate values, monthly flow records dating from January 1982 to November 1984, were analyzed statistically. Illustration 3-2 is a probability plot of the total monthly water use for any month over the period examined. As can be seen, monthly volumes have varied from 420,000 to greater than 1,737,600 gallons with one abnormal reading of 3,929,300, while the mean (50% probability of occurrence) monthly water use is approximately 1,220,000 gallon, which is equivalent to an average daily flow of 61,000 gpd. Taking into account the standard deviation of the data and the number of flow observations, calculations indicate that 95% of the time monthly water use will not exceed 1,764,500 gallons or 88,225 gpd. Examination of the historical monthly water usage also shows that most of the low monthly water use readings which were experienced over the 35 month period clustered near 900,000 gpd and occurred less than 20% of the time.

Also note that the overall flow probability curve may be approximately described by two straight lines, the line of lesser slope seemingly describing a set of flows which are relatively higher and have a higher probability of occurring than those described by the line of greater slope. That is, there appears to be two distinct sets of flow, one with high magnitudes and the other with lower values, each of which can be thought of as having a separate and distinct probability of occurrence. It is very likely that at Bremen Bearing higher magnitude flows can be correlated with higher than normal production demands, second and third shifts with more water use, while the lower flows are associated with reduced production and shut down periods or reduced water use due to operator awareness of management's concern for water conservation. Water use during the last 6 months has declined considerably despite normal production.

As a check on the statistical analysis of water use patterns, approximate field measurements were made at the discharge pipes serving the three main wastewater generating processes during a peak production time about 10 A.M. on November 13, 1984. Using V-notch weir approximations, nomographs and approximations of pipe flow velocities, the following estimates of wastewater flows were made.

TABLE 3-1
MEASURED WASTEWATER FLOWS (GPM)

| Liming Dept. | Knobbing Depth. | Heat Treat | |
|---|---|---|---|
| | | Quench Oil Wash | Tumbler Rinse |
| 21 | 17 | 22 | 17 |
| To Ponds 1 & 2 | To Pond 3 | To Ponds 1 & 2 | To Ponds 1 & 2 |

Other flows which originate over the production day would add to these instantaneous measured flows. These are the sanitary flows from restrooms and showers (estimated at 1000 GPD, 1 GPM) air conditioner which was not in use at the time of measurement (2880 GPD, 16-hr. shift 3 GPM) canner (100 GPD) miscellaneous floor and trench washings not occurring during measurement (450 GPD, 1/2 GPM).

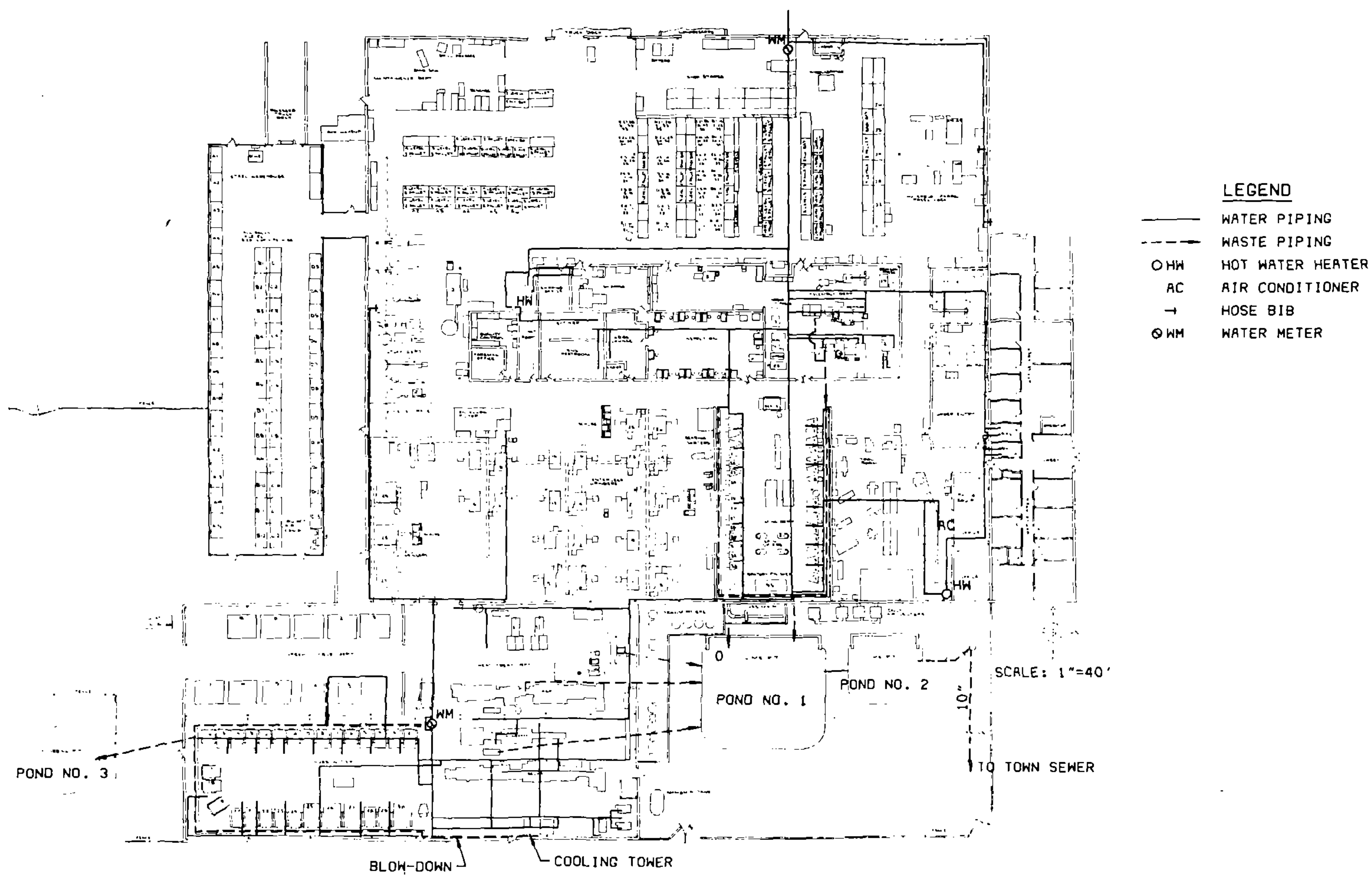
Grinding recycle water (lost to evaporation - 300 GPD), should be subtracted from the total water use figure in the water balance.

Also, evaporation from the heat treat cooling tower (1/2 GPM) should be subtracted from the total water balance. Additional flows likely not included in the measurement would be floor washings, trench washings (450 GPD, 1/2 GPM) green tumbling rinse water (1000 GPD, 1 GPM) and rinse water from tumblers not being used at the time of flow measurements (9600 GPD, 10 GPM).

TABLE 3-2
WATER BALANCE

| Peak Statistical Flow (16-hr. day) (95% Confidence not to be exceeded) | Measured Peak Flows 11/13/84 | |
|---|---|---|
| | Sum of Table 3-1 | Additional Flows Not Measured |
| 88225 GPD | 73,920 GPD | 14,400 GPD |
| 92 GPM | 77 GPM | 15 GPM |

Based on discussions with the management at Bremen Bearing, production at the Bremen plant is expected to increase by roughly 10% above 1982-84 levels within the next 3 years and then level off due to space limitations at the present site and increased output from new production facilities in other parts of the country. Partially because no other reliable basis exists for predicting future wastewater flows from Bremen Bearing, it was assumed that

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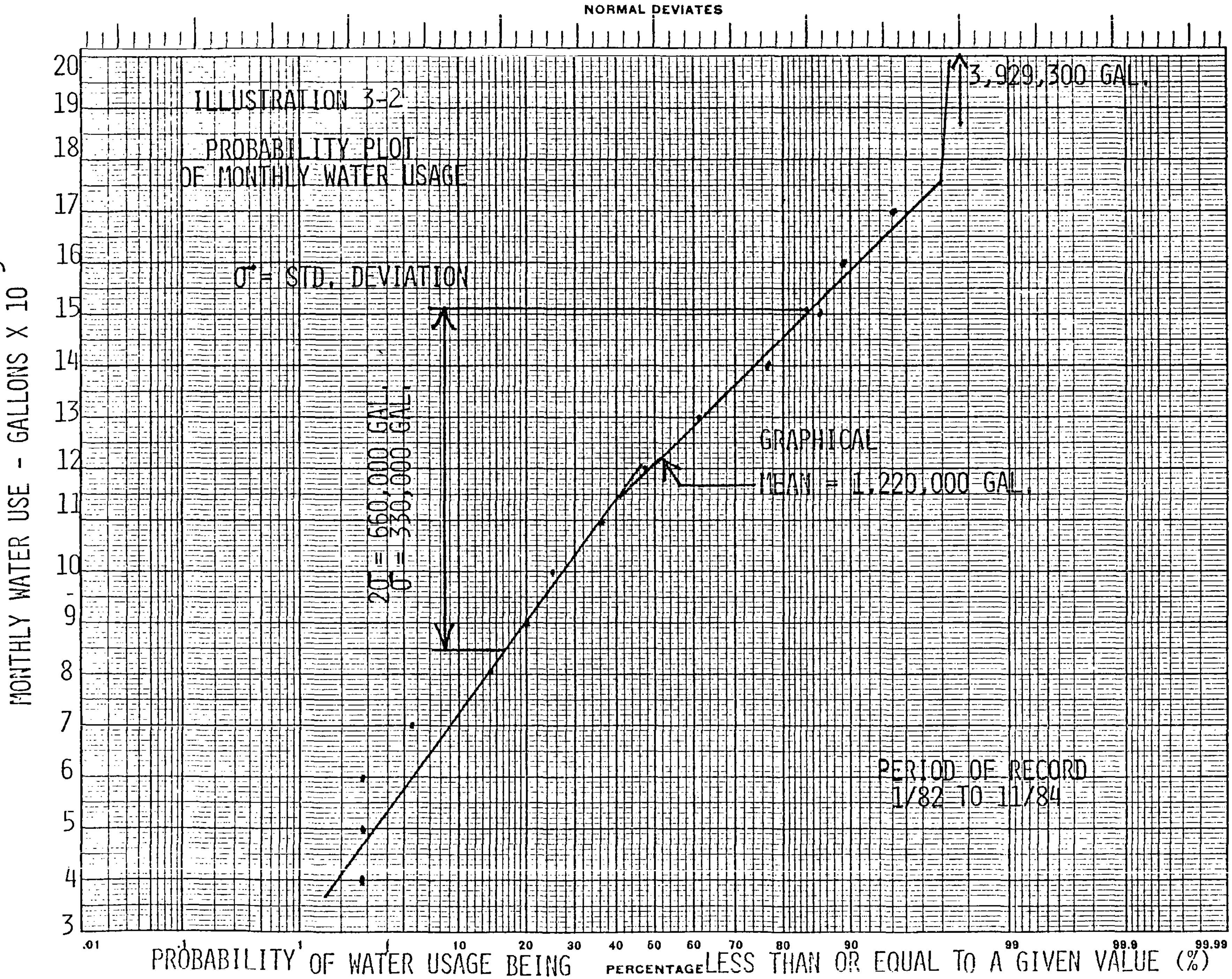
APPROXIMATE LOCATIONS OF WATER AND WASTE PIPING

BREMEN BEARING MASS FINISHING WASTES STUDY

ILLUSTRATION 3-1

FN-381 (8-53) GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., U. S. A. PROBABILITY PAPER



there would be a one to one correlation between increase in production and increase in wastewater flow rates. That is, daily average and maximum daily flows to be used for facilities design are assumed to be 10% greater than their 1982-84 counterparts. It was further assumed that an increase in production would have no affect upon peak wastewater flows. Flows to be used for design are presented in Table 3-3.

TABLE 3-3
DESIGN FLOW RATES
16-HOUR DAY

| Flow | Rate, gpd | Rate, gpm |
|---|---|---|
| Average Daily | 61,000 | 63 |
| Maximum Daily | 74,000 | 77 |
| Peak | 88,225 | 92 |

## 3.2 SOLIDS BALANCE

The solids concentration for an 8-hr. composite sample of the knobbing, liming and heat treat quench oil wash wastestreams was determined for a sample collected on September 1, 1982 and yielded a concentration of 4400 mg/l of suspended solids for an average flow for the day of 56,300 gallons or about 14,640,000 gallons per year. Over the year, this will result in pounds of solids, totaling:

lbs = 4400 mg/l x 14.6 MG x 8.34 lbs/gal.

= 535,761 lbs of solids.

From purchasing department records (Table 3-4) and Bremen Bearing personnel weight estimates of steel fines, the approximate total pounds of raw materials was estimated to be 378,472 lbs. No estimate of the amount of waste oil was given except 420 gallons per month of Amo quench which can be assumed to be washed off over the year into Pond 1 in the heat treat quench oil wash. This would yield 5040 gallons per year at 0.90 sp gr x 8.34 lbs/gal = 37,830 lbs.

This only amounts to 416,302 lbs per year of solids compared to a predicted solids total, based on flow data and the actual suspended solids test of 535,761 lbs of solids entering the ponds.

TABLE 3-4
RAW MATERIALS USAGE
(Bremen Bearing Estimate)

| | |
|---|---|
| <u>Liming Pit</u> | |
| Water | 18,000,000 gal/yr |
| Alum oxide grit | 30,000 lbs/yr |
| Lime | 16,000 lbs/yr |
| Delrod 403 | 220 gal/yr (1834 lbs) |
| Roto-Brite 59 | 4,800 lbs/yr |
| GF 6000 | 60 gal/yr (500 lbs) |
| Femco detergent powder | 13,000 lbs/yr |
| Femco F35NB | 700 gal/yr (5838 lbs) |
| Waste Oil (mostly emulsified by detergent) | 37,830 lbs (est.) |
| Steel particles | 15,000 lbs/yr |
| <u>Knobbing Pit</u> | |
| Water | 5,000,000 gal/yr |
| Aluminum oxide grit | 120,000 lbs/yr |
| Lime | 14,000 lbs/yr |
| GF 6000 | 60 gal/yr (500 lbs) |
| Femco detergent powder | 7,000 lbs/yr |
| Waste oil (emulsified) | 300 lbs/yr (est.) |
| Steel particles | 150,000 lbs/yr |

However, additional solids are lost in Pond No. 2 effluent to the Town's sewer system. Past testing records show an average pond effluent suspended solids concentration of 219 mg/l based on a composite sample taken on September 26 and 27, 1978. Again:

219 mg/l x average flow from Pond 2 x 8.34 lbs/gal

= pounds solids lost in effluent.

The average flow into Ponds 1 and 2 is the sum of the liming wastewater, heat treat quench oil wash water and tumbler rinse water and the additional waters not entering Pond 3 (excludes knobbing water). The average flow through Ponds 1 and 2 is about 43 GPM or 41,280 GPD (16-hr. shift).

Therefore:

219 mg/l 0.041 x 0.072 MGD x 20 days/mo. x 12 mos./yr x 8.34 lbs/gal

= 18,095 lbs of solids lost to sewer.

This brings the mass balance to within 16% of the solids accounted for in the raw materials:

535,761 lbs - 434,397 lbs.

The additional mass of solids can be accounted for by considering the extra solids formation occurring during lime addition to the liming tumblers. For each pound of lime added to hard water approximately three and one half pounds of solids are precipitated:

30,000 lbs lime x 3.5 = 105,000 lbs

| Based on Measured | Based on Raw Material Records |
|---|---|
| 535,761 lbs | 539,397 lbs |

The remaining 2% solids not accounted for may be attributed to some of the approximations used in these mass balance calculations.

Also, it should be noted that approximately 45-60 cubic yards of solids are removed from the ponds about every 6 months. At approximate specific weight of 250 lbs/cubic feet yields 405,000 lbs.

The above solids balance approximations are for general accounting of solids flow through the plant and are not to be taken as exact quantities. The balance is for the purpose of accounting for each possible wastestream to insure that some waste item is not being excluded from the wastes to be treated.

# 4. WASTEWATER CHARACTERISTICS AND TREATABILITY

## 4.1 WASTEWATER QUALITY AND TREATABILITY

Wastewater analyses have been conducted on the wastestreams to determine the raw wastewater characteristics to be used for design purposes.

Any waste characterization program should take into account all potential sources of waste generation. After identifying the sources of waste generation, a judgment can be made regarding their possible constituents. A chemical analysis of associated parameters can next be performed to quantify the various constituents present in the waste. After this point, the parameters which must be reduced to acceptable levels are determined and the treatment equipment is selected to carry out the removal.

Table 4-1 indicates the results of analyses on an 8-hr composite sample conducted on the wastewater entering Ponds 1, 2 and 3. The composite sample reflects the combining of a waste stream with high solids content (Pond 3; south knobbing pit) with a less concentrated solids wastestream (Pond 1, east liming pit) and with an oily wastestream from the heat treat oil quench rinse water.

TABLE 4-1
CHARACTERISTICS OF COMBINED PROCESS WASTESTREAMS

| Parameter | Concentration ppm |
|---|---|
| pH | 9.8 @ 21°C |
| $BOD_5$ | 100 mg/l |
| Suspended solids (TSS) | 4400 mg/l |
| Oil & Grease (O & G) | 87 mg/l |
| Total mercury (Hg) | 0.0025 mg/l |
| Total cadmium (Cd) | 0.05 mg/l |
| Total chromium (Cr) | 36 mg/l |
| Total copper (Cu) | 3.8 mg/l |
| Total lead (Pb) | 0.1 mg/l |
| Total nickel (Ni) | 0.4 mg/l |
| Total silver (Ag) | 0.17 mg/l |
| Total zinc (Zn) | 1.65 mg/l |
| Total phenols | 0.035 mg/l |

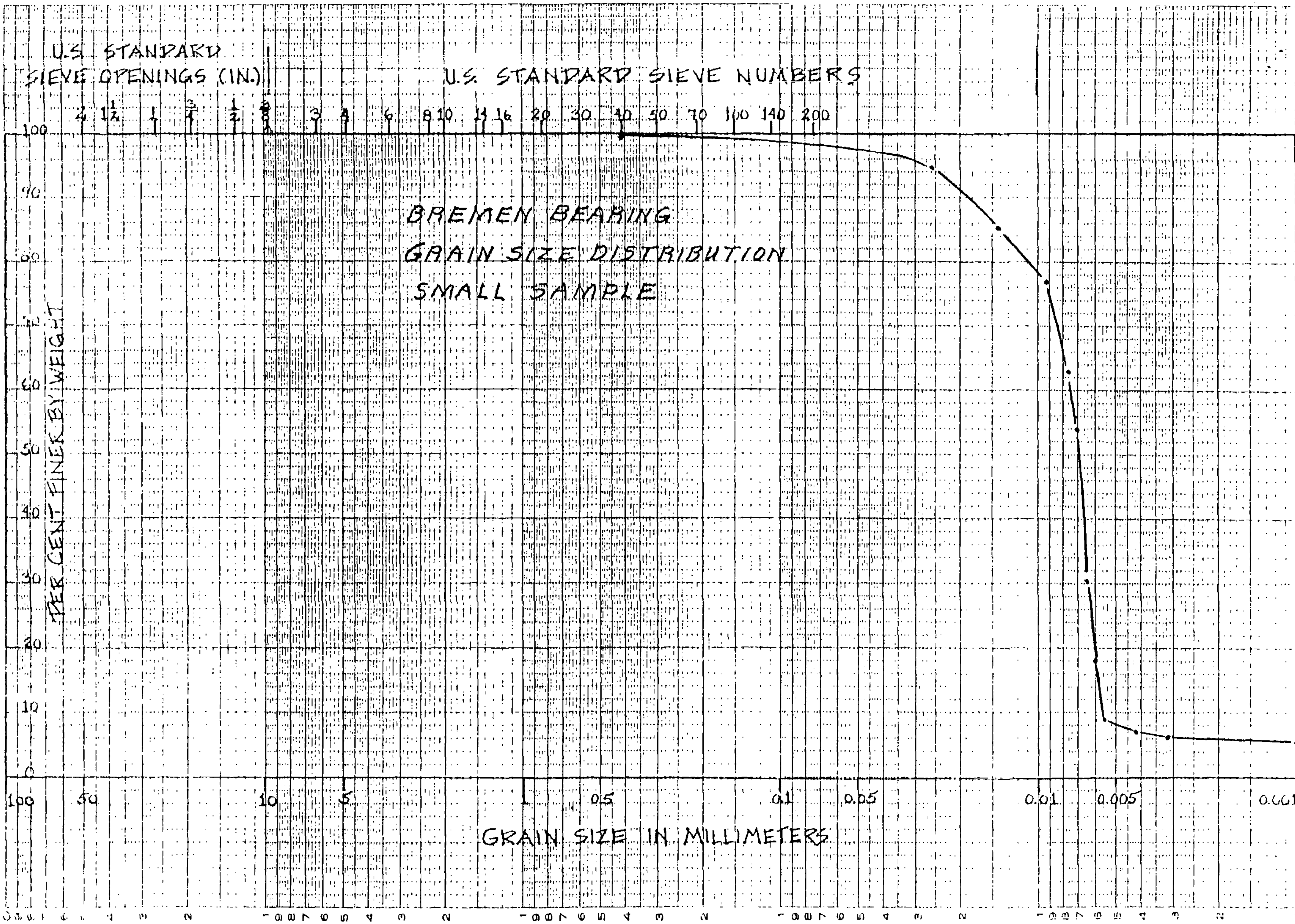
Hydrometer and sieve analyses were conducted to determine the particle size distribution, the specific gravity, and filtering characteristics of the wastestreams entering Pond No. 1 (Liming Pit) Pond No. 3 (Knobbing Pit). Results of these tests are shown in Table 4-2 and in Illustrations 4-1 through 4-4.

Results show that the particles from the knobbing wastestream (to Pond 3) are more uniform and much smaller than the particles from the liming wastestream (to Pond 1). The mean particle size for the knobbing wastestream is 9 microns and 85 percent of the particles are between 5 to 20 microns with 12 percent of the particles smaller than 5 microns. Three broad divisions of particle sizes were observed. Those larger than 400 microns, (3%), those 5 to 20 microns (85%), and those smaller than 5 microns (12%). The specific gravity of the particle slurry was 4.23.

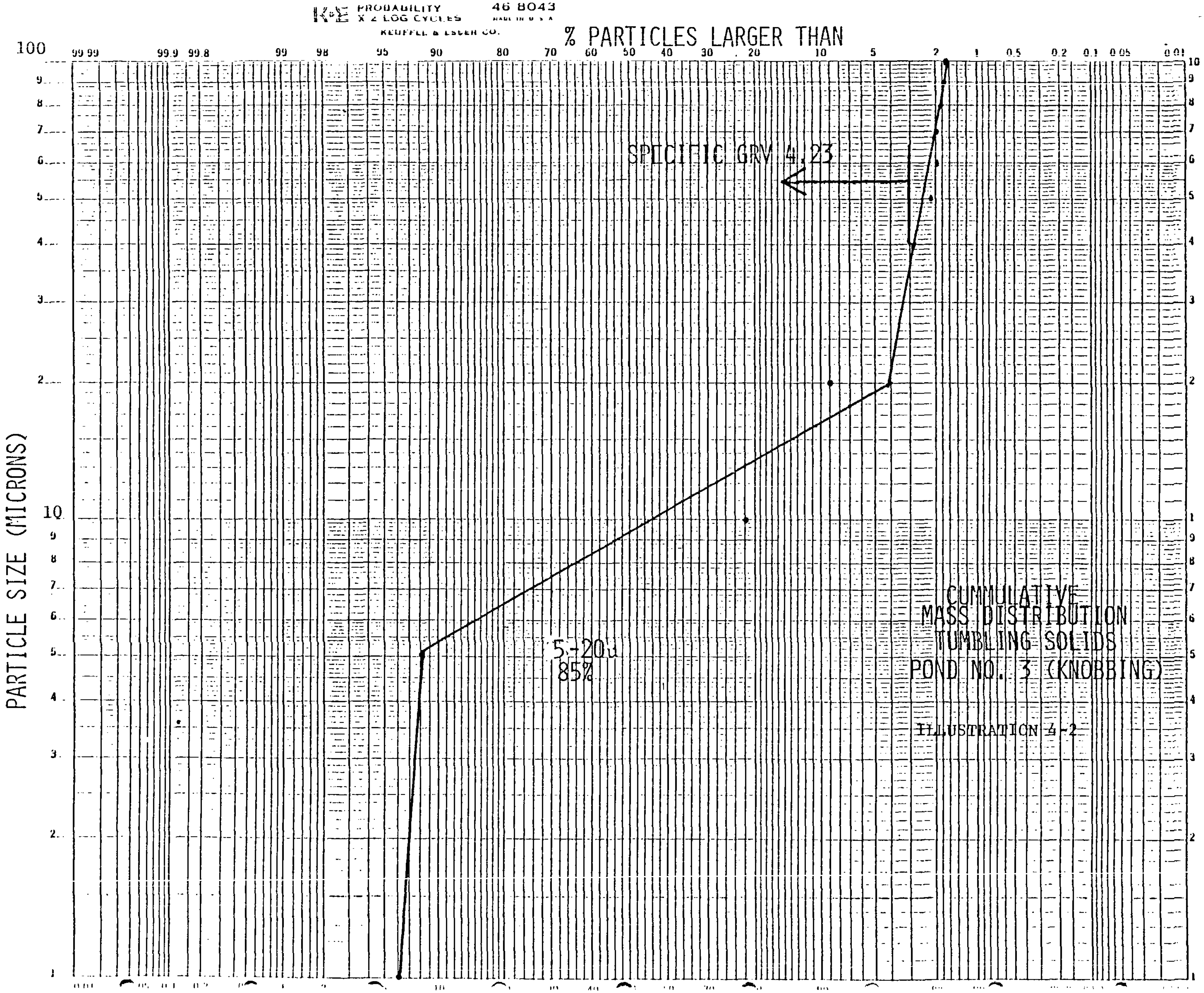
The liming wastestream (to Pond 1) contains greater diversity in particle size distribution than the knobbing wastestream and much larger particle sizes. About 84 percent of the particles are larger than 100 microns with the mean particle size being about 250 microns. The specific gravity of the particles larger than 400 microns was 2.43. For particles less than 400 microns the specific gravity was 4.32.

TABLE 4-2
RESULT OF PARTICLE SIZE DISTRIBUTION TESTS

| Wastestream | Range of Particle Size (Microns) | | |
|---|---|---|---|
| | Less than 5, | 5-20 | Greater than 100 |
| Pond No. 1 (Liming Slurry Oil removed) | 11% | 5% | 84% |
| Pond No. 3 (Knobbing Slurry) | 12% | 85% | 3% |

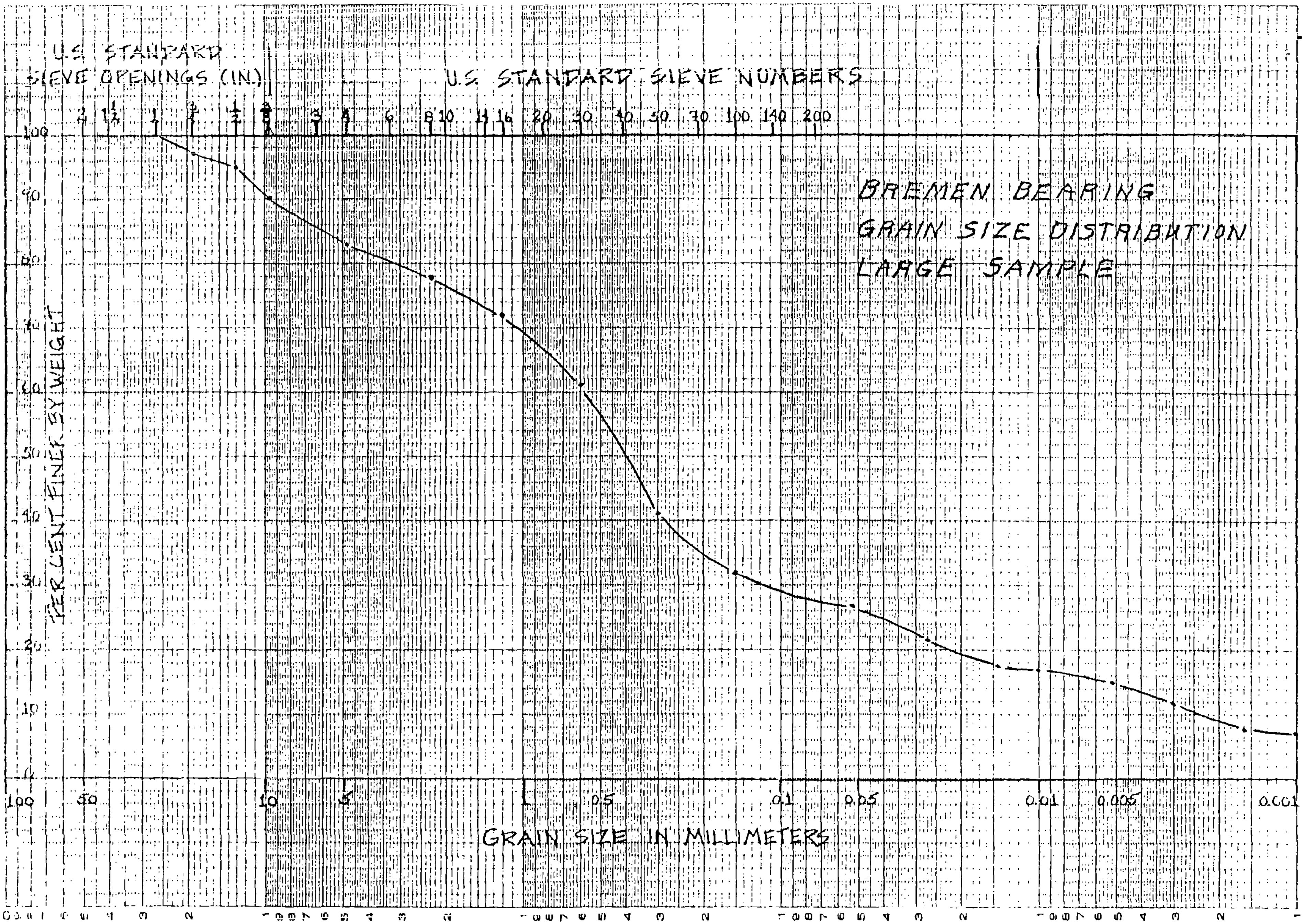


BREMEN BEARING
GRAIN SIZE DISTRIBUTION
SMALL SAMPLE
U.S. STANDARD SIEVE OPENINGS (IN.)
U.S. STANDARD SIEVE NUMBERS
PER CENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS


K+E PROBABILITY X 2 LOG CYCLES
46 8043
KEUFFEL & ESSER CO.
% PARTICLES LARGER THAN
PARTICLE SIZE (MICRONS)
SPICIFIC GRV 4.23
5-20u
85%
CUMMULATIVE
MASS DISTRIBUTION
TUMBLING SOLIDS
POND NO. 3 (KNOBBING)
ILLUSTRATION 4-2

These tests show that the knobbing wastestream with the higher specific gravity is faster settling than the liming wastestream. The knobbing wastestream contains a more dense, compact, and finer particle mass than the liming wastestream. Even though the knobbing particles settle faster, the finer particles are more prone to being disturbed by turbulence in normal settling conditions such as in the settling ponds or clarifiers. The liming particles are lighter and settle very slowly but are also very filterable. The smaller particles being above 5 microns in the knobbing wastestream are easily filtered and dewaterable as demonstrated by filtering tests.

Specific filter resistance tests were conducted for the knobbing particle slurry, the liming particles slurry without oil removed, and the liming particle slurry with oil removed. The specific resistance was determined from laboratory data using a Buchner funnel apparatus (Illustration 4-5) recording the quantity of liquid filtered over time and weighing the amount of material filtered. The mass of filtered solids per unit volume of filtrate was also determined. Results are shown in Table 4-3.

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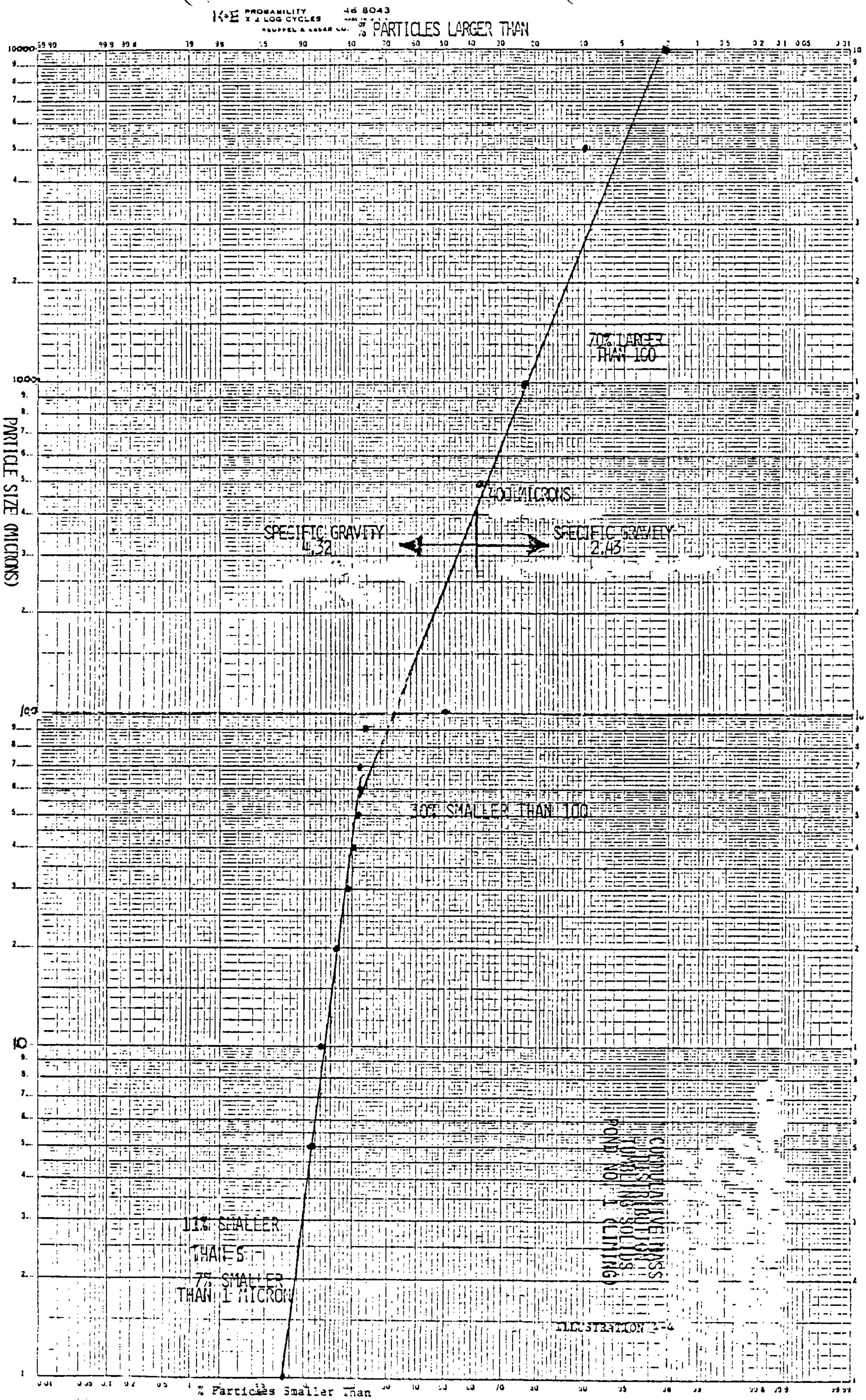
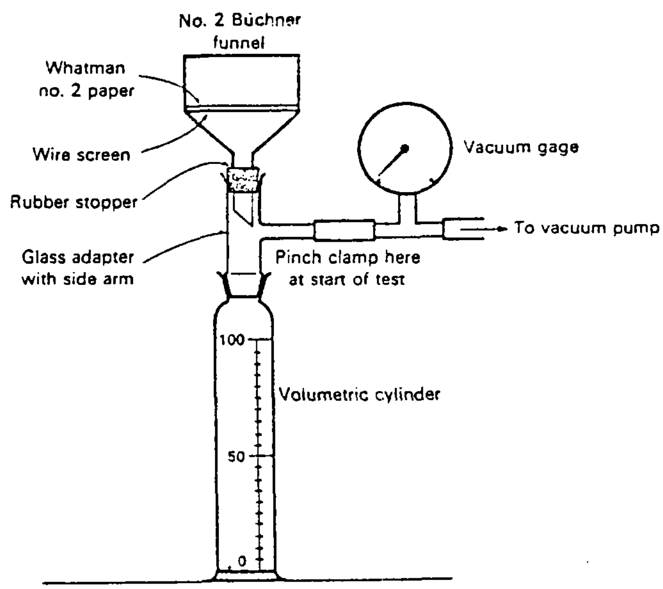

K+E PROBABILITY X 2 LOG CYCLES 46 8043
KEUFFEL & ESSER CO.
% PARTICLES LARGER THAN
PARTICLE SIZE (MICRONS)
% Particles Smaller Than
70% LARGER THAN 100
40 MICRONS
SPECIFIC GRAVITY 4.32
SPECIFIC GRAVITY 2.43
30% SMALLER THAN 100
11% SMALLER THAN 5
7% SMALLER THAN 1 MICRON
CUMULATIVE MASS
DISTRIBUTION
TUMBLING SOLIDS
POND NO. 1 (LIMING)
ILLUSTRATION

TABLE 4-3
FILTERING CHARACTERISTICS

| Wastestream | Specific Resistance $Sec^2/g$ | Filter Yield Pounds of Dry Solids per Hour-$Ft^2$ |
|---|---|---|
| Pond No. 1 (Liming Slurry with oil) | $1.0 \times 10^7$ | 1.42 |
| Pond No. 1 (Liming Slurry without oil removed) | $1.2 \times 10^6$ | 3.81 |
| Pond No. 3 (Knobbing Slurry) particles less than 400 microns | $3.7 \times 10^5$ | 6.37 |
| Pond No. 3 (Knobbing Slurry) particles larger than 400 microns | $7.1 \times 10^4$ | 14.48 |

*Test conducted using Buchner funnel, No. 2 (5 micron) filter paper with area of 95 $cm^2$. Test pressure was 15 inches Hg for Buchner Test. Pressure for determining filter yield was 4 inches of Hg or 2 PSI. Absolute viscosity (centipoise) used in the test was that of water at 60°F to simulate actual operating temperature and assumes that most oil has been removed prior to filtering.




Buchner funnel test apparatus used for the determination of the specific resistance

ILLUSTRATION 4-5

The viscosity of the wastestreams is an important parameter in defining filtering characteristics. The higher the viscosity (thicker, slower flowing) of a liquid the smaller the flow of the liquid through a filter cake and medium.

The viscosity of the separated oil from Pond No. 1 was measured using a Saybolt Universal Viscometer (Fisher Scientific; Method ASTM D88). At 100°F the viscosity in Saybolt Seconds Universal (SSU) was 100. When converted to units of absolute viscosity, the value becomes 17.1 centipoise. It was assumed that the specific gravity of the separated oil was 0.83. This is based on the known specific gravity value for Amoquench SF which is used in the heat treat oil quench.

In an oil separation test, oil readily separated from Pond No. 1 (Liming Liquid), this observation favors the possibility of oil separation and recovery for sale. The oil and grease concentration entering Pond No. 1 (Liming Pit) was 3383 mg/l. The oil and grease concentration entering Pond No. 3 was 381 mg/l.

The characteristics of the dried solids from Pond No. 1 and Pond No. 3 are shown in Table 4-4.

TABLE 4-4
FINAL SOLIDS CHARACTERISTICS OF COMBINED
POND 1 (LIMING PIT) AND POND 3 (KNOBBING PIT)

| PARAMETER | | CONCENTRATION |
|---|---|---|
| pH | | 8.9% |
| Total Solids | | 77.85% |
| Flash Point, F° | greater than | 212 |
| Ash Content, on ignition | | 76.56% |
| Arsenic, mg/l | | 15.4 |
| Barium, mg/l | | 50.6 |
| Cadmium, mg/l | | 6.85 |
| Chromium, mg/l | | 1,500 |
| Copper, mg/l | | 208 |
| Iron, mg/l | | 175,000 |
| Lead, mg/l | | 117 |
| Mercury, mg/l | | 0.0398 |
| Nickel, mg/l | | 141 |
| Selenium, mg/l | less than | 0.04 |
| Silver, mg/l | | 5.34 |
| Zinc, mg/l | | 155 |

Analysis by Chemical Waste Management 5/11/84

Company estimates give the yearly amount of steel fines generated at about 165,000 lbs. The current cash price for scrap iron is about $85/ton (Wall Street Journal 12/10/84). A metal reclaimer in South Bend, Indiana (Metal Resources Corp.) quoted a price for the purchase of steel fines at $5/ton delivered. For the purposes of this study it is assumed that the dried steel fines from Bremen Bearing may be sold for between $5 and $20 per ton.

The metal fines from the Knobbing Pond No. 3 were determined to consist of a highly magnetic powder after filtration. This test result indicates that treatability using a magnetic separator may be feasible.

## 4.2 APPLICABLE EFFLUENT STANDARDS

Since Bremen Bearing does not perform electroplating, electroless plating, anodizing, coating (phosphating, chromating, and coloring), chemical etching and milling, or printed circuit board manufacture, it is not considered in the category of Metal Finishing and thus is not regulated by Federal Categorical Pretreatment Standards (p 32464 Federal Reg. July 15, 1983 40 CFR Parts 413 and 433).

Because the wastewater from Bremen Bearing would be pretreated and discharged to the Town of Bremen sewers, the local industrial waste ordinance would govern the effluent quality of the treated wastewater. These standards are tabulated below in Table 4-5.

TABLE 4-5
TREATED EFFLUENT DESIGN PARAMETERS

| Parameter | Maximum Concentrations |
|---|---|
| Cadmium | 0.75 |
| Chromium | 3.0 |
| Copper | 0.6 |
| Cyanide | 1.0 |
| Lead | 0.4 |
| Mercury | 0.001 |
| Nickel | 3.0 |
| Silver | 0.24 |
| Zinc | 3.0 |
| pH | 6.0 - 9.0 |
| Oil and Grease | 100 |
| BOD | 250 |
| Suspended Solids | 250 |

## 5. EVALUATION OF TREATMENT ALTERNATIVES

### 5.1 GENERAL

Due to the nature of the wastestreams, primarily a solids slurry, and the ultimate goal of eliminating the existing solid settling ponds, the treatment methods reviewed were limited to those with minimum space requirements and high rate solids processing capabilities.

The alternatives investigated were:

1. Equalization, oil segregation, filtration, direct discharge to Town sewer.

2. Equalization, oil segregation, filtration, water reuse, and discharge to Town sewer.

The process alternatives considered for oil segregation were air flotation, coalescing oil separator, and other gravity separators. The process alternatives considered for filtration were vacuum filtration, centrifugation, and liquid cyclone separation.

Based on the information presented in previous sections of this report and on discussions with Bremen Bearing personnel, the following design considerations were utilized in the preliminary design of and comparison of alternative treatment systems.

1. Oil to be removed prior to filtration. Oil to be sold to a reclaimer (Wayne Reclamation).

2. Design flow rates are:

| | |
|---|---|
| Average Daily Flow | 63 GPM |
| Maximum Daily Flow | 77 GPM |
| Peak Daily Flow | 92 GPM |

3. Filtered water to be reused in rinsing operations in the liming and knobbing departments.

4. Solids loading of 4400 mg/l.

5. Heavy metals are precipitated at alkaline pH's and are filtered out with the solids.

6. Oily wastestream may need to be acidified to break oil emulsion due to detergents.

7. Plant operation based on a 16-hour day.

## 5.2 EQUALIZATION

Equalization is the collection of fluctuating wastestream flows in a central holding tank prior to further treatment for the purpose of smoothing out flow surges that result from daily plant operation production variations.

The qualization proposed for Bremen Bearing is sized to store 3-hours of the normal production wasteflow at 60 GPM or about 10,000 gallons. The equalization tank will be located underneath the flat bed vacuum filter and will receieve flows from the magnetic separator oil separator and the liming sump prior to filtering.

## 5.3 OIL SEPARATION

Treatment of oily wastes can be carried out most efficiently if oils are segregated from other wastes and treated separately. Segregated oily wastes originating in the tumbling and heat treat areas can be collected in holding tanks and sumps. After separation, oil and grease concentrations can be as high as 400,000 mg/l. Combined oily wastes are those generated from washing or rinsing of oily parts, spills, and leakages and generally have lower oil and grease concentrations than segregated oily wastes by several orders of magnitude. Furthermore, oily wastes in combined wastewater streams, such as common metals wastewaters, require larger and thus more costly treatment systems for oils removal than do segregated oily wastewaters because of the combined wastewaters have significantly greater flow rates.

Many different types (or compounds) of oils and related fluids are common in oily wastes and include cutting oils, fluids, lubricants, greases, solvents, and hydraulic fluids. Segregation of these oily wastes from other wastewaters reduces the expense of both the wastewater treatment and the oil recovery process by minimizing the quantity and number of constituents involved. In addition, segregated oily wastes are appropriate for hauling to disposal or reclamation by a contractor in lieu of on-site treatment. Additional segregation of oil wastes by type or compound can further reduce treatment or hauling costs. Some oils have high reclaimer values and are more desirable if they are not contaminated by other oils.

Properly segregated spent oils containing common base oils and additives will retain much more of their original value and can be efficiently processed. Spent oils, properly segregated, can be processed in-house or sold to an outside contractor. Some plants purchase reprocessed oils which results in substantial savings. One such oil recycler is Renco Oil of South Bend, Indiana who can provide quench oil and recycle it at about $0.50 less per gallon than once through quench oil.

The washing of oil metal parts, rinses following oil quenches, machine system leaks, and some testing washes or rinses produce the largest majority of the oily wastewater. Steps should be taken in-plant to segregate cutting fluids, hydraulic oils, crankcase oil, quench oils, and solvents from these waste streams.

Treatment of segregated oily wastes consists of separation of the oily wastes from the water. This separation can require several different steps depending on the character of the oily wastes involved. If the oils are all of a free or floating variety, physical means such as decantation or the use of a gravity oil separator should be used to remove the oils. If the oily wastes are emulsified, techniques such as emulsion breaking or dissolved air flotation with the addition of chemicals are necessary to accomplish removal of the oils. Once the oil-water emulsion is broken, the oily waste is physically separated from the water by decantation or skimming.

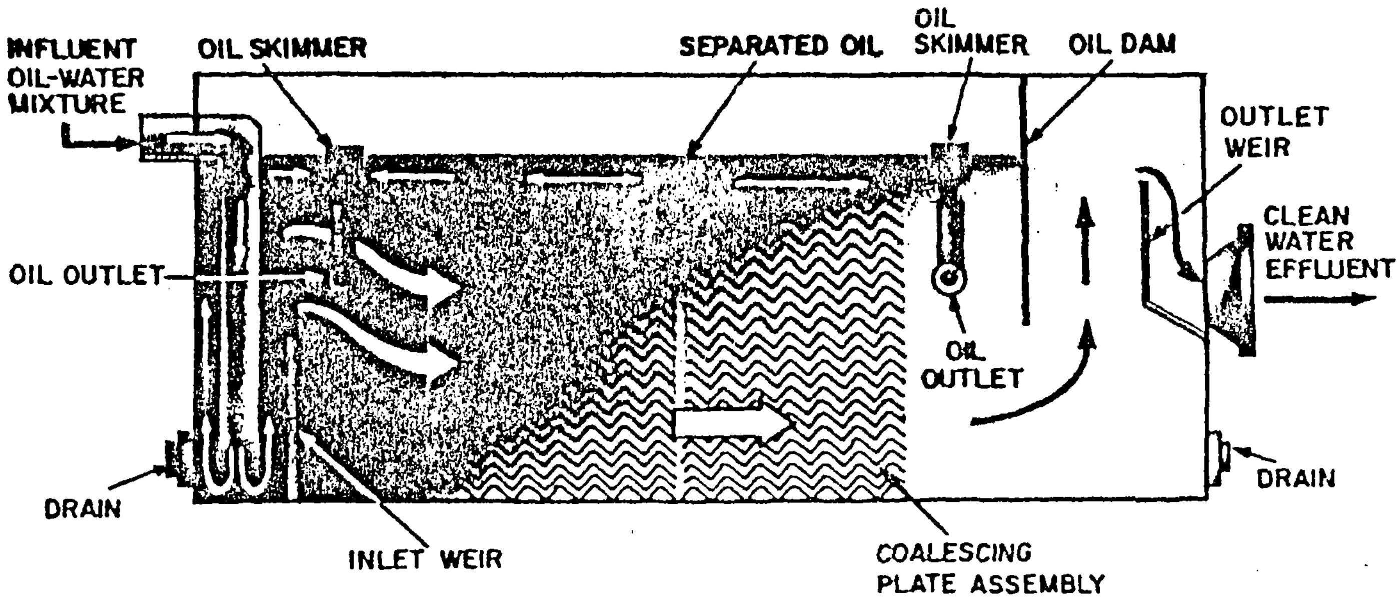
Coalescing

The basic principle of coalescing involves the preferential wetting of a coalascing medium by oil droplets which accumulate on the medium, and then rise to the surface of the solution. The most important requirements for coalescing media are wettability for oil and large surface area.

Coalescing stages may be integrated with a wide variety of gravity oil separation devices, and some systems may incorporate several coalescing stages. In general, the provision of preliminary oil skimming treatment is desirable to avoid overloading the coalescer. One commercially marketed system for oily waste treatment (see Illustration 5-1) combines coalescing with gravity separation. In this unit, the oil waste enters the separator where the large droplets immediately move to the top surface of the separator because of the specific gravity differential. The smaller droplets enter the corrugated plate area where laminar flow produces coalescing of the oil droplets. The oil droplets deposit on the surface of the plates and stream upward through weep holes in the plates to the surface, where adjustable skimmers remove the oil. Heavy solids are deposited in the entrance chamber before the oily wastewater enters the plate area.

Coalescing is used in the Metal Finishing Category for treatment of oily wastes. It allows removal of oil droplets too finely dispersed for conventional gravity separation/skimming technology. It can also significantly reduce the residence times (and therefore separator volumes) required to achieve separation of oil from some wastes. Because of their simplicity, coalescing oil separators provide generally high reliability and low capital and operating costs. Coalescing is not generally effective in re-

ILLUSTRATION 5-1




COALESCING GRAVITY SEPARATOR

moving soluble or chemically stabilized emulsified oils. To avoid plugging, coalescers must be protected by pretreatment from very high concentrations of free oil and grease and suspended solids. Frequent replacement of prefilters may be necessary when raw waste oil concentrations are high.

Coalescing is inherently highly reliable because there are no moving parts, and the coalescing substrate is inert in the process and therefore not subject to frequent regeneration or replacement requirements. Large loads or inadequate prior treatment, however, may result in plugging or bypassing of coalescing stages. Also, the presence of detergents may prevent the oil droplets from absorbing properly on the coalescer materials. Maintenance requirements are generally limited to replacement of the coalescing medium on an infrequent basis.

No appreciable solid waste is generated by this process, but when coalescing occurs in a gravity separator, the normal solids accumulation is experienced.

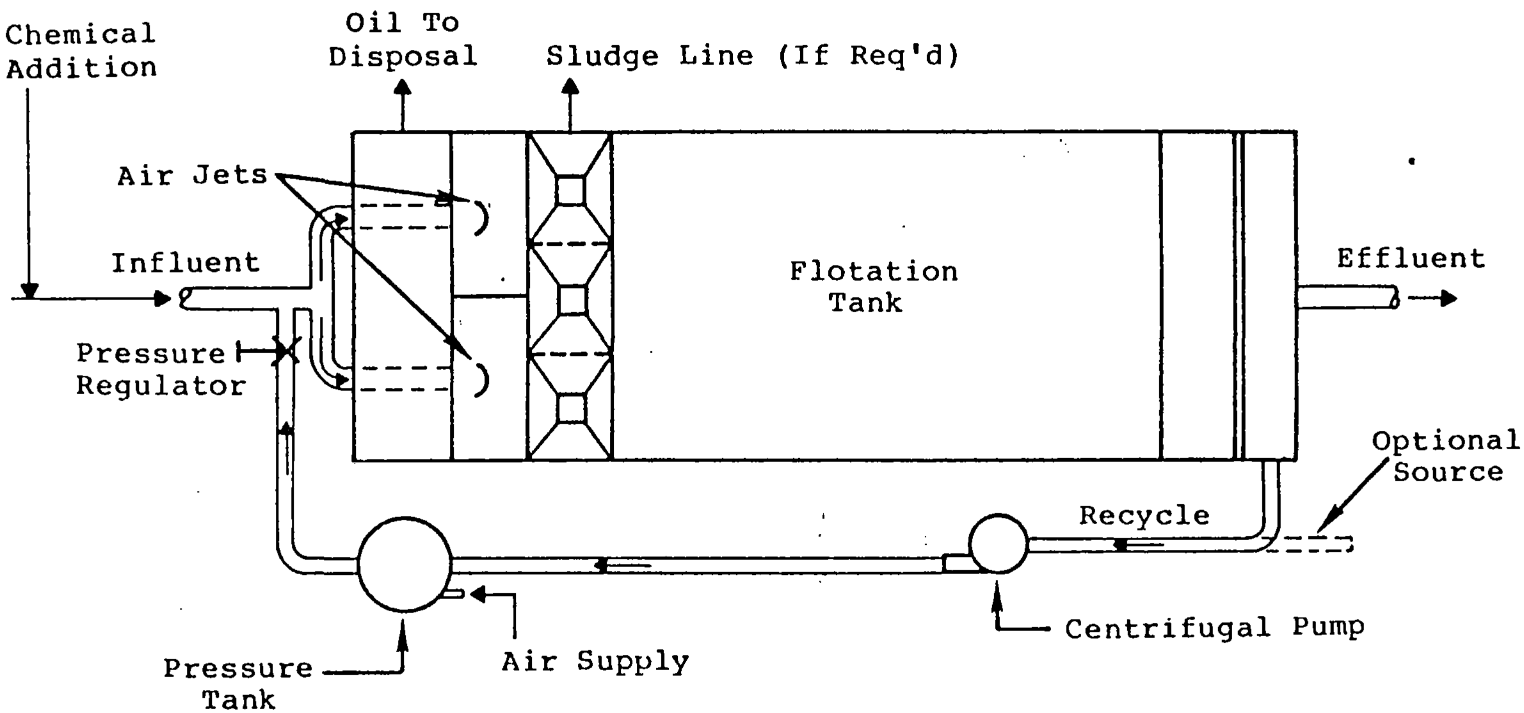
Flotation

Flotation is the process of causing particles such as oil or metal hydroxides to float to the surface of a tank where they can be concentrated and removed. This is brought about by releasing gas bubbles which attach themselves to the particles, increasing their buoyancy, causing them to rise to the surface and float. Flotation units are commonly used in industrial operations to remove free and emulsified oils and grease. For these applications, the flotation technique commonly referred to as dissolved air flotation (DAF) is employed. Dissolved air flotation utilizes emulsion breaking techniques that uses the bubbles of dissolved air to assist in the agglomeration of the oily droplets and to provide increased buoyancy for raising the oily droplets to the surface. A typical dissolved air flotation system is shown in Illustration 5-2.

The use of dissolved air for oily waste flotation subsequent to emulsion breaking can provide better performance in shorter retention times (and therefore smaller flotation tanks) than with emulsion breaking without flotation. A small reduction in the quantity of chemical for emulsion breaking is also possible. Dissolved air flotation units have been used successfully, in conjunction with further subsequent processes, to reclaim oils for direct reuse.

The performance of a flotation system depends upon having sufficient air bubbles present to float essentially all of the suspended solids. An insufficient quantity of air will result in only partial flotation of the solids, and excessive air will yield no improvement. The performance of a flotation unit in

ILLUSTRATION 5-2




TYPICAL DISSOLVED AIR FLOTATION SYSTEM

terms of effluent quality and solids concentration in the float can be related to an air/solids ratio. The shape of the curve obtained will vary with the nature of the solids in the feed.

Skimming

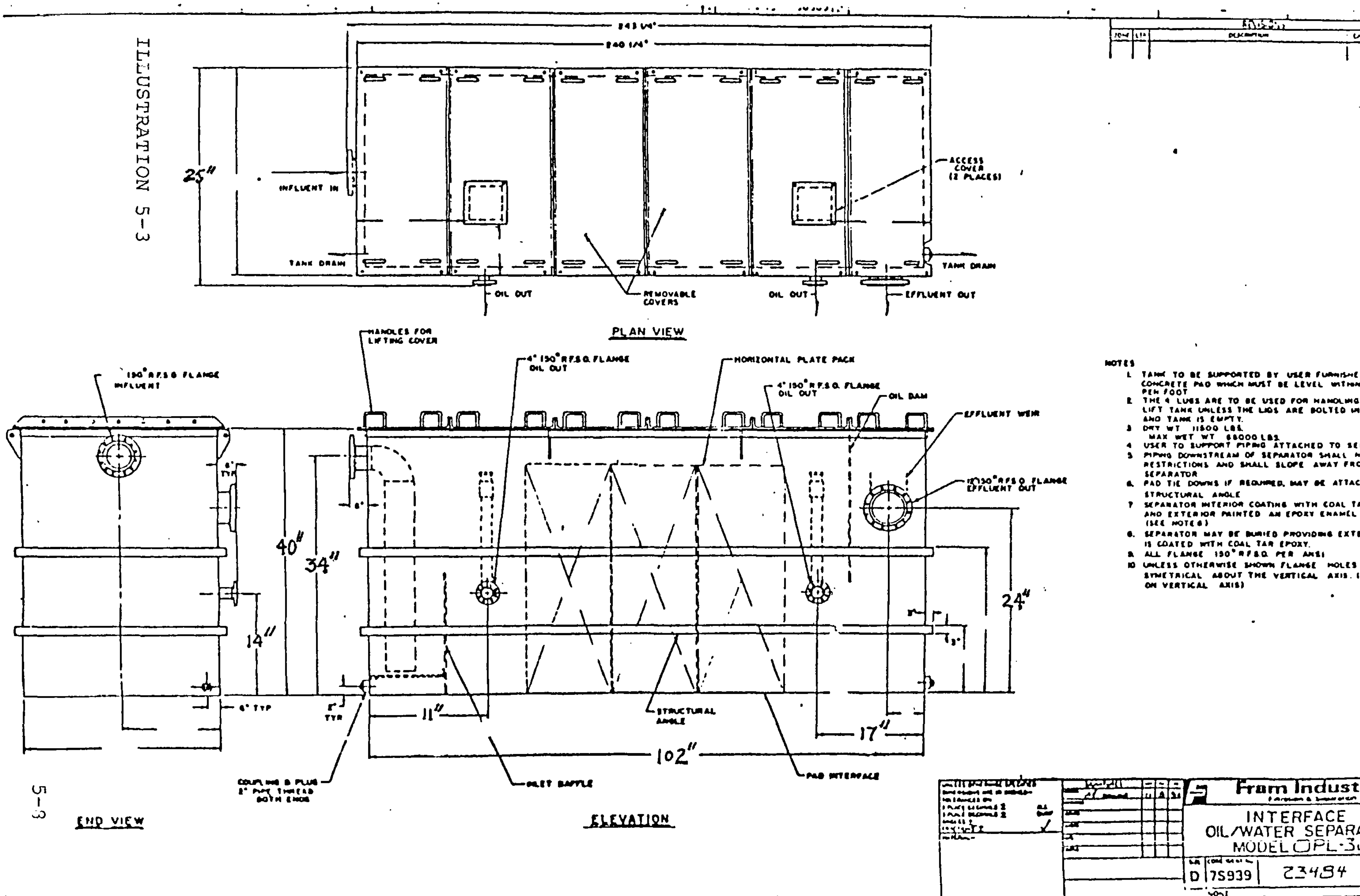
Skimming is used to remove floating wastes and normally takes place in a tank designed to allow the debris (with a specific gravity less then water) to rise and remain on the surface. Skimming devices are therefore suited to the removal of oily wastes from raw waste streams after demulsification. Common skimming mechanisms include the rotating drum type, which picks up oil from the surface of the water as it rotates. A knife edge scrapes oil from the drum and collects it in a trough for disposal or reuse. The water portion is then allowed to flow under the rotating drum. Occasionally, an underflow baffle is installed after the drum; this has the advantage of retaining any floating oil which escapes the drum skimmer. The belt type skimmer is pulled vertically through the water, collecting oil from the surface which is again scraped off and collected in a tank. System design and operational controls are important in drum and belt type skimmers in order to ensure uniform flow through the system and avoid oil bypassing the skimmer mechanism.

Gravity separators, such as the API type, utilize overflow and underflow baffles to skim a floating oil layer from the surface of the wastewater. An overflow-underflow baffle allows a small amount of wastewater (the oil portion) to flow over into a trough for disposition or reuse while the majority of the water flows underneath the baffle. This is followed by an overflow baffle, which is set at a height relative to the first baffle such that only the oil bearing portion will flow over the first baffle during normal plant operation. An inlet diffusion device, such as a vertical slit baffle, aids in creating a uniform flow through the system and increasing oil removal efficiency.

Skimming is applicable to any waste stream containing pollutants which float to the surface. Skimming is used in conjunction with emulsion breaking, dissolved air flotation, clarifiers, and other sedimentation devices.

API or other gravity-type separators are more suitable for use where the amount of surface oil flowing through the system is consistently significant as with free oils. Drum, belt, or rotary type skimmers are applicable to waste streams which carry smaller amounts of floating oily waste and where surges of floating oil are not a problem. The use of a gravity separator system preceding emulsion breaking is a very effective method of removing free oil constituents from oily waste streams.

ILLUSTRATION 5-3



Skimming as a pretreatment is effective in removing naturally floating waste materials, such as free oils, and improves the performance of subsequent downstream treatments. Many pollutants, particularly dispersed or emulsified oil, will not float "naturally" but require additional treatments. Therefore, skimming alone will not remove all the pollutants capable of being removed by more sophisticated technologies.

Because of its simplicity, skimming is a very reliable technique, however, a mechanical skimming mechanism requires periodic lubrication, adjustment, and replacement of worn parts.

The collected layer of debris (scum) must be disposed of in an approved manner. Because relatively large quantities of water are present in the collected wastes, direct combustion or incineration is not always possible.

Centrifugation

Centrifugation is the process of applying a centrifugal force to cause the separation of materials. This force is many times the force of gravity so it allows for solids separation in a much shorter time than that required by settling. When a suspension is centrifuged, the components of the solution with the greatest specific gravity accumulate at the farthest distance from the axis of the centrifuge and those with the least specific gravity are located nearest the axis. So when oily wastes containing suspended solids are centrifuged, the solids portion collects at the outside of the centrifuge, the oil forms the innermost layer, and the water portion is sandwiched in between. The different layers that are formed can then be collected separately. Centrifuges are currently available that have been specifically designed to separate either oil/water mixtures or oil/solids/water mixtures. Centrifugation equipment is in use as a pretreatment technique to separate oil/water mixtures prior to further wastewater treatment.

Emulsion Breaking

Emulsion breaking is a process by which emulsified oils are removed from oil/water mixtures. Emulsified oils are commonly used as coolants, lubricants, and anitoxidants for many of the unit operations performed in the Metal Finishing Category. Methods of emulsion breaking include a variety of chemical processes, thermal processes, and combinations of the two processes. These techniques are discussed in the following paragraphs.

Chemical emulsion breaking can be accomplished either as a batch process or a continuous process. A typical system (with skimming incorporated) is illustrated in Illustration 5-11. The mixture of

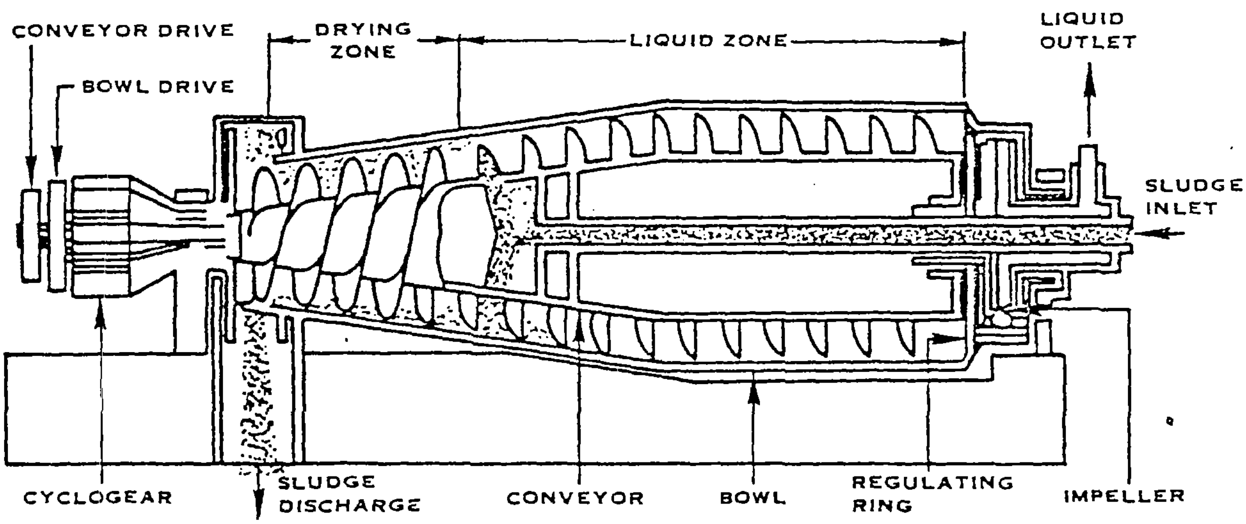
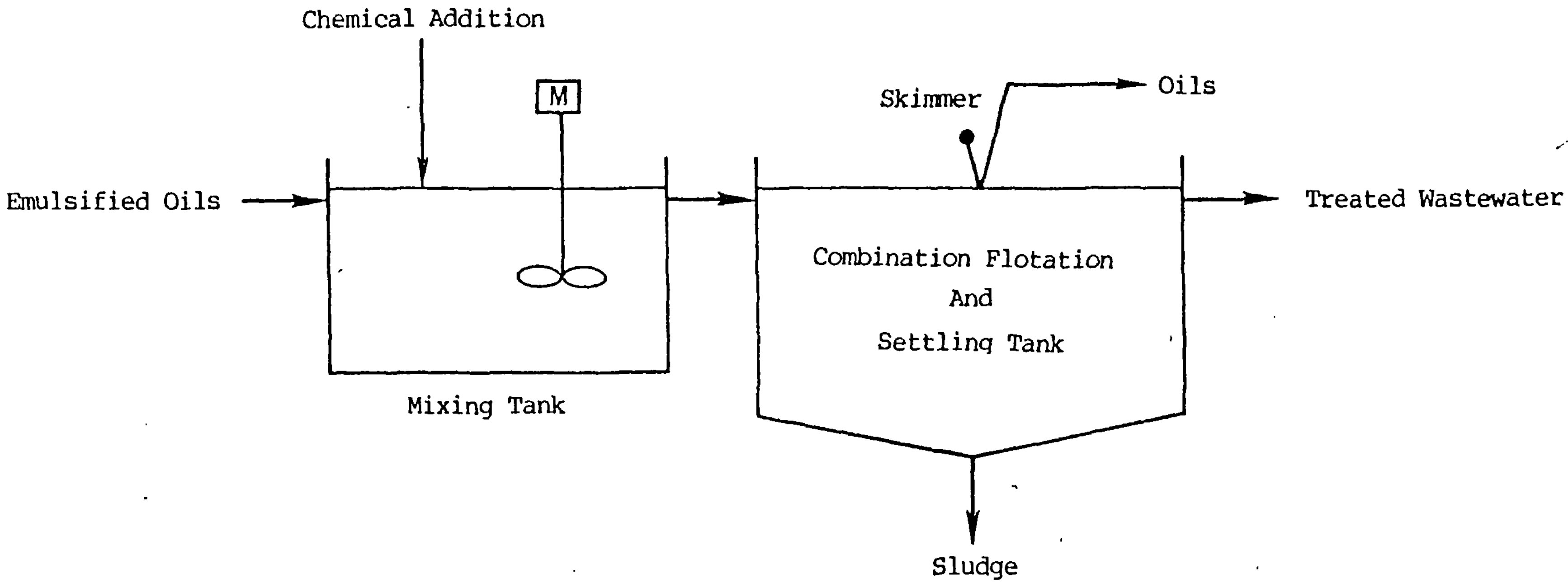



ILLUSTRATION 5-4

CENTRIFUGATION




TYPICAL EMULSION BREAKING/SKIMMING SYSTEM emulsified oils and water is initially treated by the addition of chemicals to the wastewater. A means of agitation (either mechanical or by increasing the turbulence of the wastewater stream) is provided to ensure that the chemical added and the emulsified oils are adequately mixed to break the oil/water emulsion bond. Finally the oily residue (commonly called scum) that results rises to the surface and is separated from the remaining wastewater by a skimming or decanting process. The skimming process can be accomplished by any of the many types of mechanical surface skimmers that are presently in use. Decanting methods include removal of the oily surface residue via a technique such as controlled tank overflow or by removal of the demulsified wastewater from the bottom of the tank. Decanting can be accomplished with a series of tap-off lines at various levels which allow the separated oils to be drawn off the top or the wastewater to be drawn off the bottom until oil appears in the wastewater line. With any of these arrangements, the oil is usually diverted to storage tanks for further processing or hauling by a licensed contractor.

Chemical emulsion breaking can be accomplished by a large variety of chemicals which include acids, salts, or polymers. These chemicals are sometimes used separately, but often are required in combination to break the various emulsions that are common in the wastewater. Acids are used to lower the pH to 3 or 4 and can cleave the ion bond between the oil and water, but can be very expensive unless acid rich wastewaters, such as pickling wastes, can be used. Acids are more commonly employed in oil recovery systems than in oily waste removal systems. Iron or aluminum sulfate are more commonly used because they are less expensive. These salts combine with the wastewater to form acids which in turn lower the pH and break the oil/water bond (and have the additional benefit that these salts aid in agglomeration of the oil droplets), but the use of these salts produces more sludge because of the addition of iron or aluminum. Polymers, such as polyamines or polyacrylates and their copolymers, have been demonstrated to be effective emulsion breakers and generate less sludge than do metal salts.

Oil Recovery

Reprocessing of Oil - Reprocessing consists of contaminant removal by physical separation, filtering, centrifuging, or magnetic separation, as previously discussed. Reprocessing also includes the preparation of waste oils for burning as a fuel supplement.

Reclamation of Oil - Oil reclamation combines the elements of reprocessing along with mechanical or chemical steps. Reclamation is used to remove solids and water, fuel or solvents, and degradation products such as acid. Two common processes are flash distillation and chemical adsorption. The addition of heat with a partial vacuum and filtration are employed to remove degradation products in used oil.

Reclamation is used with synthetic fluids or highly refined mineral oils. Reclamation systems are available for either fixed or portable operation, and outside reclamation services are available.

Recycling of Oil - Recycling is the most comprehensive treatment. The waste oil is prefiltered to remove most of the solids, solvents/fuel, and water, leaving essentially base oil and additives. Removing the additives leaves a high quality basestock. The basestock is then formulated with conventional additives and can be used in the same application as the virgin basestock. Re-refining provides the best economics when large volumes of waste oil are available. Re-refiners may accept industrial oil wastes when a large source or many smaller sources of waste oils are available for collection in a region.

Current value for reclaimed oil is from $0.15 to $0.20 per gallon. Proposed reglations by the U.S. Environmental Protection Agency to become effective in March 1985, will likely have an impact on reclaimed oil prices. These regulations will place reclaimed oil in the category of hazardous waste for those who accept oil for reclamation. The generators of the reclaimed oil will not be required to comply with any additional regulations except to obtain an ID number and prepare manifest papers to accompany shipments of waste oil to the reclaimer. Because of these additional hazardous waste requirements and expense placed on the reclaimer, the price paid for reclaimed oil may be less than the current price.

## 5.4 SOLIDS REMOVAL

### Vacuum Filtration

In wastewater treatment plants, sludge dewatering by vacuum filtration is an operation that is generally accomplished on cylindrical drum filters. These drums have a filter medium which may be cloth made of natural or synthetic fibers, coil springs, or a wire-mesh fabric. The drum is suspended above and dips into a vat of sludge. As the drum rotates slowly, part of its circumference is subject to an internal vacuum that draws sludge to the filter medium. Water is drawn through the porous filter cake to a discharge port, and the dewatered sludge, loosened by compressed air, is scraped from the filter mesh. Because the dewatering of sludge on vacuum filters is relatively expensive per kilogram of water removed, the liquid sludge is frequently thickened prior to processing. A vacuum filter is shown in Illustration 5-6.

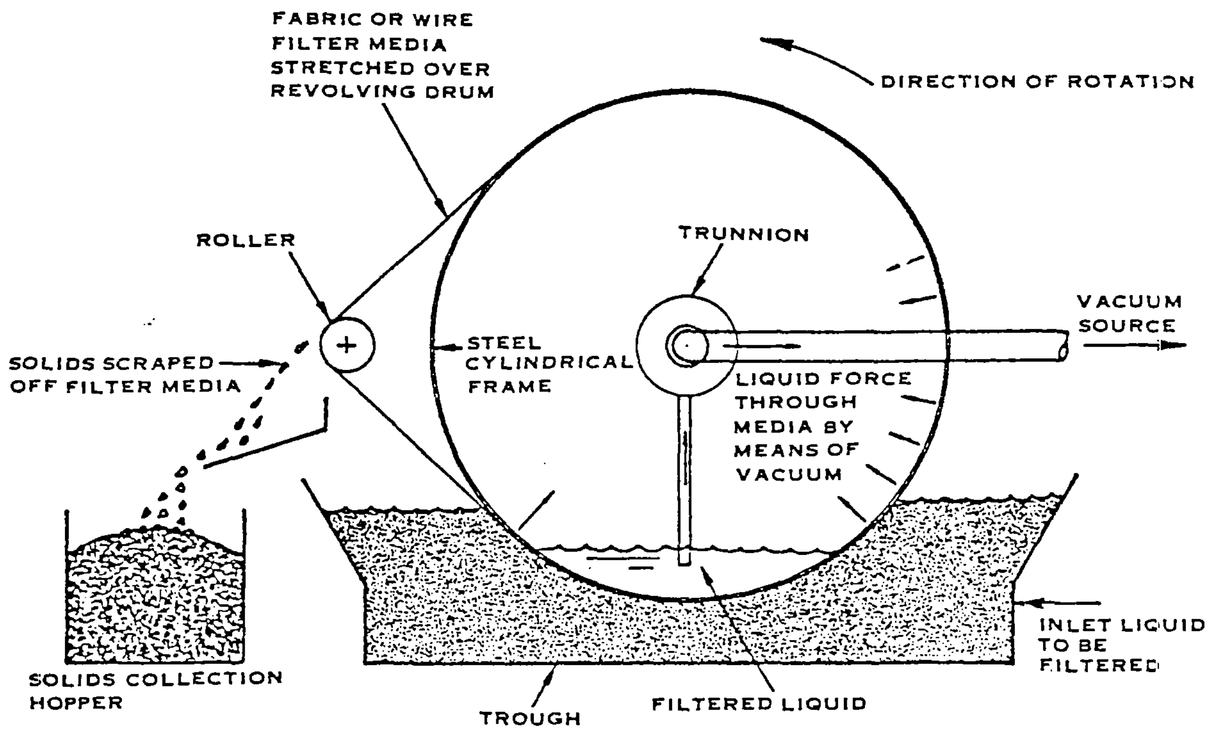



ILLUSTRATION 5-6

VACUUM FILTRATION

Vacuum filters are frequently used both in municipal treatment plants and in a wide variety of industries for dewatering sludge. They are most commonly used in larger facilities, which have a thickener to double the solids content of clarifier sludge before vacuum filtering.

Although the initial cost and area requirement of the vacuum filtration system are higher than those of a centrifuge, the operating cost is lower, and no special provisions for sound and vibration protection need be made. The dewatered sludge from this process is in the form of a moist cake and can be conveniently handled.

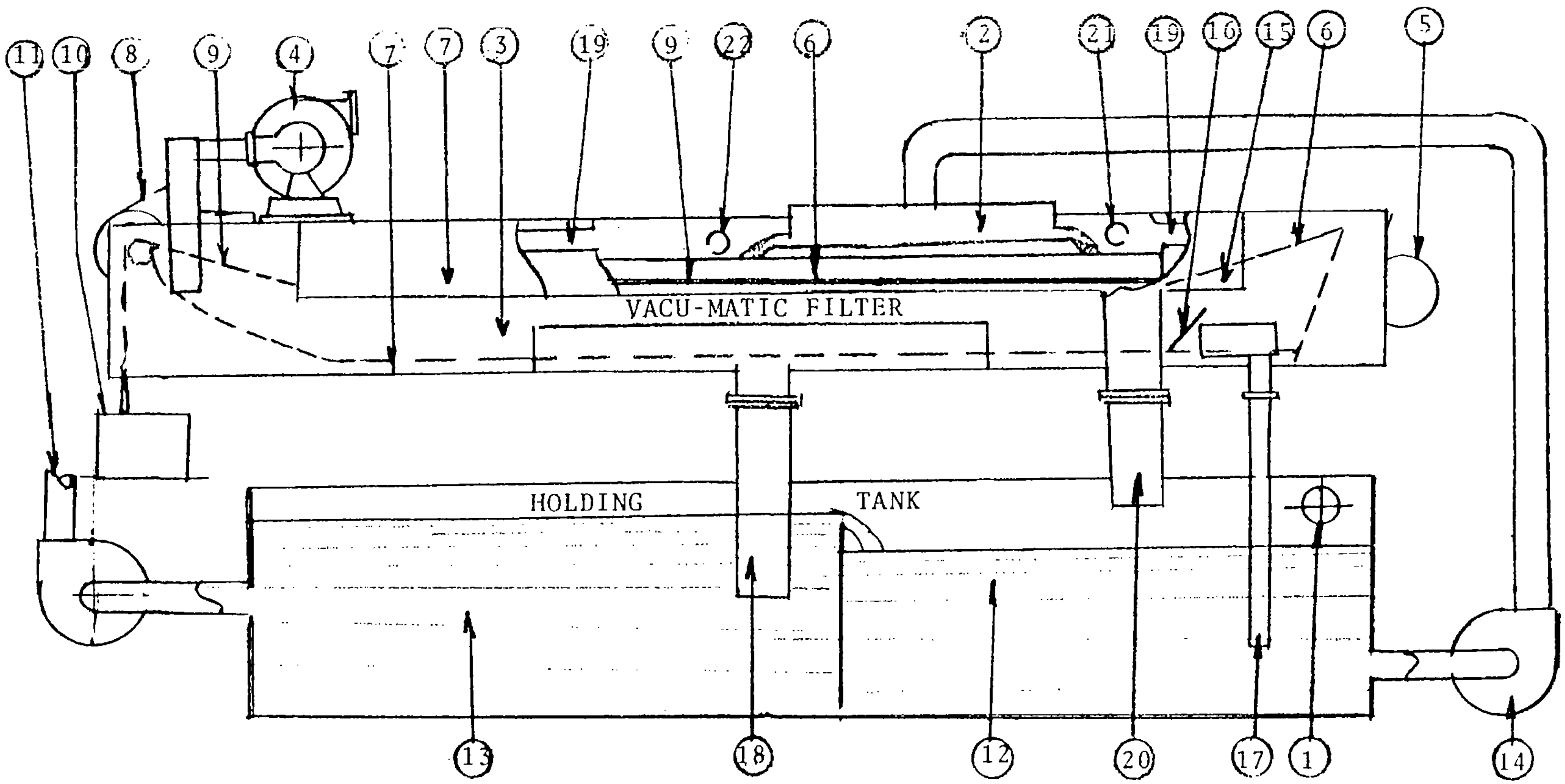
Maintenance consists of the cleaning or replacement of the filter media, drainage grids, drainage piping, filter pans, and other parts of the equipment. Experience in a number of vacuum filter plants indicates that maintenance consumes approximately 5 to 15 percent of the total time. If carbonate buildup or other problems are unusually severe, maintenance time may be as high as 20 percent. If intermittent operation is to be employed, the filter equipment should be drained and washed each time it is taken out of service and an allowance for wash time should be made in the selection of sludge filtering schedules.

Vacuum filters generate a solid cake. All of the metals extracted from the plant wastewater are concentrated in the filter cake as hydroxides, oxides, sulfides, or other salts. These metals are transported along with the solid cake to a landfill for disposal.

Another type of vacuum filter is the flat bed vacuum filter that reclaim, clarify, and recycle a broad spectrum of liquids including coolants, processing liquids and wastewaters resulting from industrial operations. (Illustrations 5-7 and 5-8)

These filters are self-cleaning, self-contained, automatic and continuous in operation, discharging essentially a dry cake filtered from the contaminated liquid. The filtering bed consists of an endless metal conveyor belt supporting the filter's media passing over a vacuum chamber. The supporting metal conveyor belt dips down into the filter body from both ends of the filter forming a deep basin. This basin collects and holds a pool of incoming contaminated liquid until it is drawn downward through the filter cake and filter media into the vacuum chamber below.

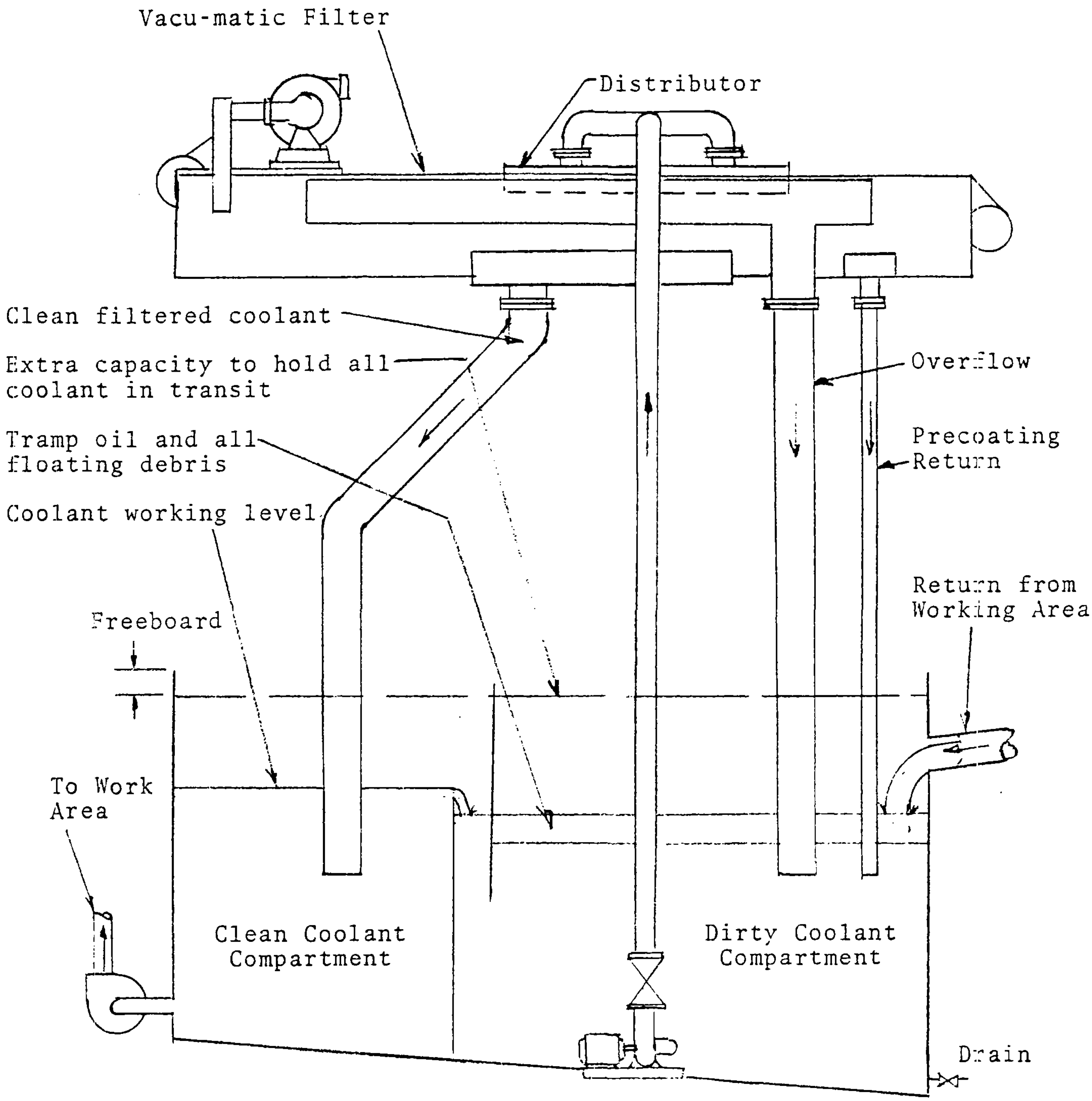
A distributor located above the filter spreads the incoming contaminated liquid evenly and gently across the pool of liquid so as to avoid disturbing the filter cake forming on the media. A centrifugal compressor acting as an exhauster creates a negative pressure in the vacuum chamber beneath the filter media. Metal particles, dirt, sludge, being deposited on the filter media




HI-FLO VACU-MATIC FILTER

LEGEND

1. Incoming Contaminated Liquid from Work Area.
2. Contaminated Liquid Distributor.
3. Vacuum Chamber.
4. Vacuum Producer or Exhauster.
5. Roll of Clean Filter Media.
6. Disposable Filter Media in Filter Bed.
7. Endless Metal Media Belt.
8. Media Conveyor Drive.
9. Filter Cake.
10. Filter Cake and Spent Filter Media in Container.
11. Clean Liquid Recirculation Pump to Work Area.
12. Contaminated Liquid Compartment in Holding Tank.
13. Clean Liquid Compartment in Holding Tank.
14. Filter Feed Pump.
15. Filter Media Precoating Section.
16. Bottom Baffle.
17. Contaminated Liquid Water Leg.
18. Clean Liquid Water Leg.
19. Overflow Slot.
20. Overflow Drain Pipe.
21. Air Skimmer Header for Loose Emulsion.
22. Air Skimmer Header for Tramp Oil




ARRANGEMENT USED WHERE FLOW TO
VACU-MATIC FILTER EXCEEDS FLOW TO
WORK AREA

ILLUSTRATION 5-8

create a filter cake which keeps increasing in thickness. When the filter cake first forms, openings in the filter media become bridged by the larger particles decreasing the size of the passageway through which the liquid must flow. Thus, as the cake progressively deepens the passageways diminish so that particles removed from the contaminated liquid continue to decrease in size. The filter cake now has been the filtering element.

As the filter cake increases in thickness the porosity of the filter cake decreases which decreases the flow of liquid through the cake. As the porosity decreases, the pool of liquid and the negative pressure in the vacuum chamber increases. Suitable instrumentation activates the motor drive to move the spent filter media laden with filter cake toward the discharge end of the filter. Concurrently, fresh media is drawn onto the filter which offers little resistance to flow so that the level of the liquid pool and the negative pressure in the vacuum chamber decrease causing the media to stop moving. As these actions occur automatically there is no interruption to liquid flow through the filter during media indexing.

As the liquid passes through the filter it leaves the filter media as a shower of droplets which fall to the bottom of the vacuum chamber. These fine drops are exposed to the air traversing the vacuum chamber. The intimate mixing of air imparts the temperature of the air and in the case of water base liquids some evaporation occurs. This evaporation, too, tends to keep the temperature of the liquid at room temperature.

The exposure of the droplets too, has an added advantage in that increased oxygen transfer from air to liquid occurs. This satisfies the biochemical demand (BOD) of the liquid which inhibits the growth of microorganisms which tend to shorten the life of the solution.

The force urging the liquid through the filter cake and filter media results from the depth of liquid on the filter cake, plus the vacuum in inches of mercury in the vacuum chamber.

Centrifugation

Centrifugation is the application of centrifugal force to separate solids and liquids in a liquid/solid mixture or to effect concentration of the solids. The application of centrifugal force is effective because of the density differential normally found between the insoluble solids and the liquid in which they are contained. As a waste treatment procedure, centrifugation is applied to dewatering of sludges. One type of centrifuge is shown in Illustration 5-4.

There are three common types of centrifuges: the disc, basket, and conveyor type. All three operate by removing solids under the influence of centrifugal force. The fundamental difference between the three types is the method by which solids are collected and discharged.

In the disc centrifuge, the sludge feed is distributed between narrow channels that are present as spaces between stacked conical discs. Suspended particles are collected and discharge continuously through small orifices in the bowl wall. The clarified effluent is discharged through an overflow weir.

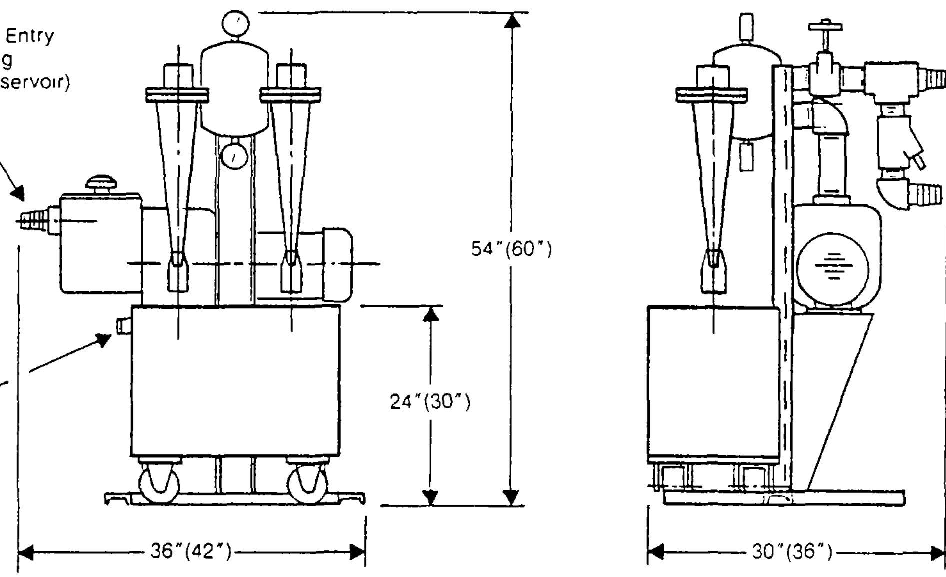
A second type of centrifuge which is useful in dewatering sludges is the basket centrifuge. In this type of centrifuge, sludge feed is introduced at the bottom of the basket, and solids collect at the bowl wall while clarified effluent overflows the lip ring at the top. Since the basket centrifuge does not have provision for continuous discharge of collected cake, operation requires interruption of the feed for cake discharge for a minute or two in a 10 to 30 minute overall cycle.

The third type of centrifuge commonly used in sludge dewatering is the conveyor type. Sludge is fed through a stationary feed pipe into a rotating bowl in which the solids are settled out against the bowl wall by centrifugal force. From the bowl wall, they are moved by a screw to the end of the machine, at which point they are discharged. The liquid effluent is discharged through ports after passing the length of the bowl.

Virtually all of those industrial waste treatment systems producing sludge can utilize centrifugation to dewater it. Centrifugation is currently being used by a wide range of industrial concerns.

Sludge dewatering centrifuges have minimal space requirements and show a high degree of effluent clarification. The operation is simple, clean, and relatively inexpensive. The area required for a centrifuge system installation is less than that required for a filter system or sludge drying bed of equal capacity, and the initial cost is lower.

Centrifuges have a high power cost that partially offsets the low initial cost. Special consideration must also be given to providing sturdy foundations and soundproofing because of the vibration and noise that result from centrifuge operation. Adequate electrical power must also be provided since large motors are required. The major difficulty encountered in the operation of centrifuges has been the disposal of the concentrate which is relatively high in suspended, nonsettling solids.




Bracketed Dimensions are for 85 and 100 G.P.M. Sub-Systems Equipped with 50 Gallon Swarf Trolley.

## Component Specifications

**WHIRLSTREAM® HYDROCYCLONE:** Polyurethane assembly rated at 165°F maximum liquid temperature.

**FILTER PUMP:** Self-priming centrifugal with removable basket strainer.

**PIPING:** All piping consists of black steel pipe.

**VALVES:** Output control valve is heavy duty gate type with brass body.

**GAUGES:** Input (0-60 P.S.I.) and output (0-15 P.S.I.)

**RELIEF VALVE:** Bronze, spring backed type, factory set to open full at 12 P.S.I.

**INPUT FITTING:** 2" hose coupling.

**HOSE:** Use standard industrial rubber water hose rated at 50 P.S.I. (not included).

**ELECTRICAL CONTROLS (optional):** 3 pole, size 1, manual starter, with overload protection, in a NEMA 12 enclosure, with Liquid-Tite flexible conduit.

**OR**

**ELECTRICAL CONTROLS (optional):** NEMA 12 enclosure with AC magnetic starters, start and stop buttons, 110 volt single phase control circuit, fused disconnect and Liquid-Tite flexible conduit.

## Technical Data

| | W20-SUB | W40-SUB | W60-SUB | W85-SUB | W100-SUB |
|---|---|---|---|---|---|
| **FLOW RATE** (GPM) | 20 | 40 | 60 | 85 | 100 |
| **HOPPER CAPACITY** (Cu. Yd.) | ⅛ | ⅛ | ⅛ | ¼ | ¼ |
| **WHIRLSTREAM® HYDROCYCLONES** (Number in System) | 1 | 2 | 3 | 4 | 5 |
| **HYDROCYCLONE PRESSURE** (PSI) | 35 | 35 | 35 | 35 | 35 |
| **CLEAN RETURN PRESSURE** (PSI) | 10 | 10 | 10 | 10 | 10 |
| **WEIGHT** (Pounds) | 450 | 460 | 470 | 475 | 500 |
| **MOTORS** (HP)* | 1 | 2 | 3 | 3 | 5 |

*Motors are three phase, 60 cycle and are available in the following standard voltages. 208, 230, or 460.

ILLUSTRATION 5-9

Reliability is high, assuming proper control of factors such as sludge feed, consistency, and temperature. Pretreatment such as grit removal and coagulant addition may be necessary. Pretreatment requirements will vary depending on the composition of the sludge and on the type of centrifuge employed.

Maintenance consists of periodic lubrication, cleaning, and inspection. The frequency and degree of inspection required varies depending on the type of sludge solids being dewatered and the maintenance service conditions. If the sludge is abrasive, it is recommended that the first inspection of the rotating assembly be made after approximately 1,000 hours of operation.

Cyclone Separator

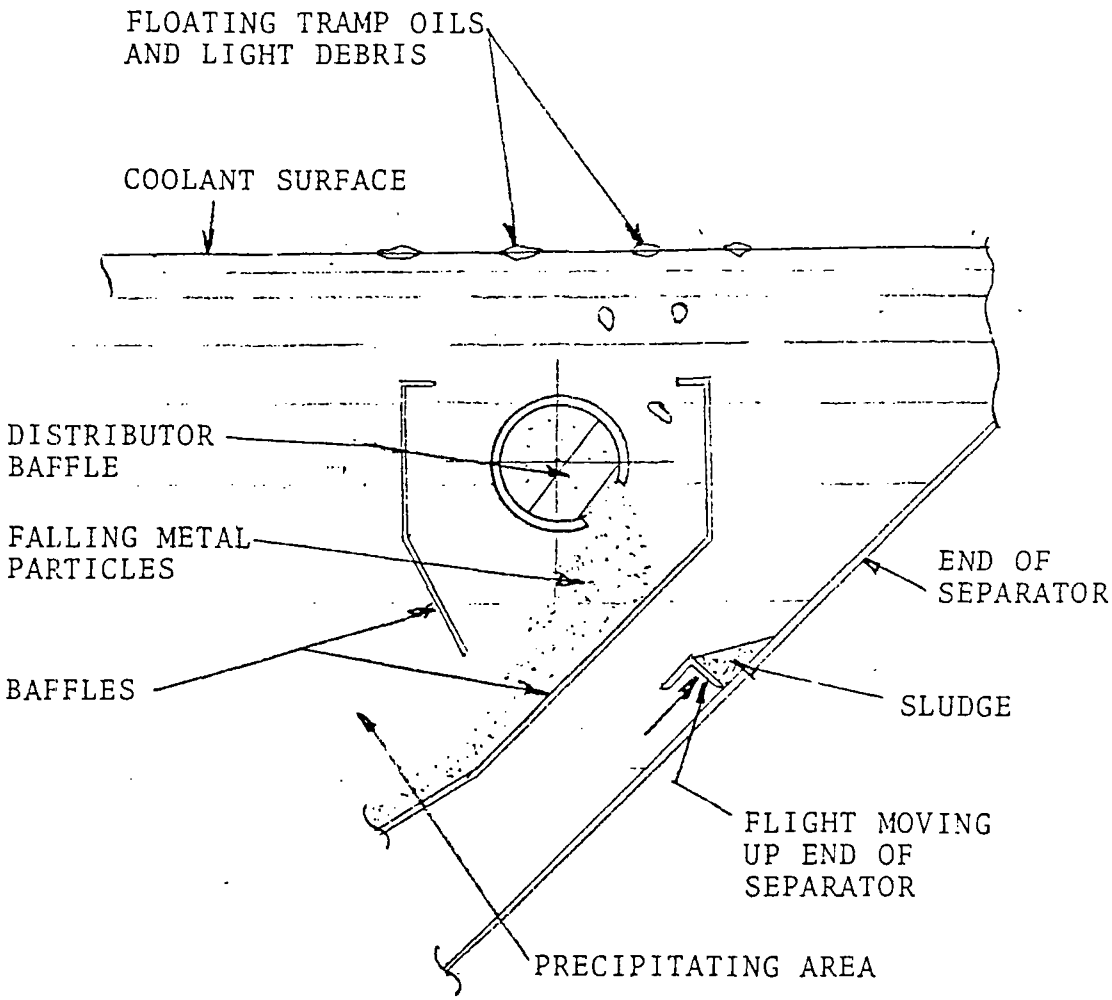
An example of a cyclone separator is the whirlstream filtration system by Polyclon, this system is guaranteed to remove 98 percent of all particles larger than 5 microns with a specific gravity greater than 1.5 (Illustration 5-9). From Table 4-2, about 12 percent by weight of the solids is less than 5 microns, therefore a concentration of solids for one-pass water treated with the Polyclon unit would be about 528 mg/l. As the water is continually reused a build-up of particles smaller than five microns would occur and a much higher concentration of solids would be expected. Theoretically the removal efficiency of various particle sizes could be increased by an increase in the velocity of water through the cyclones and a change in the physical dimensionals of the cyclone.

The system operates on the principle that materials of different densities can be separated by centrifugal force. The wastestream is introduced at high velocity through the inlet opening into a whirl chamber. As the liquid spirals downward in the conical separation chamber, its velocity increases. Solids are thrown against the walls, forced to the bottom and discharged through a nozzle. As the whirling stream approaches the bottom it reverses direction and the liquid now clarified, flows upwards through a vortex tube and out through an outlet.

## 5.5 FERROUS PARTICLE REMOVAL

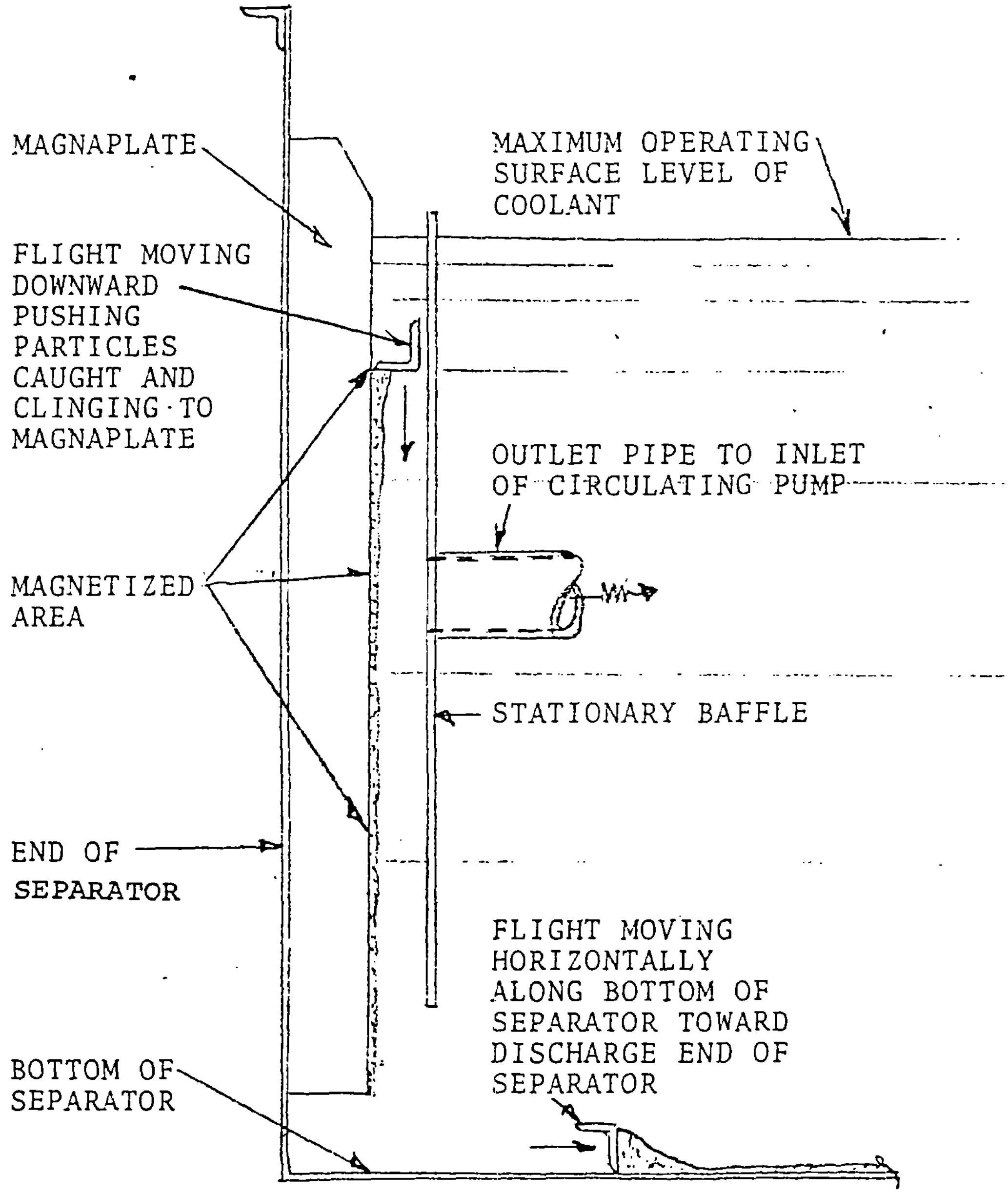
Magnetic separators clarify mineral oil coolants, water soluble coolants and other liquids carrying magnetic particles and swarf. These separators are ideal for use in central coolant filtration systems serving steel and cast iron grinding and machining operations.

The coolant flooding the cutting tools during machining operations conveys swarf, metal particles and sludge to the settling compartments of the separator where large particles drop free of the



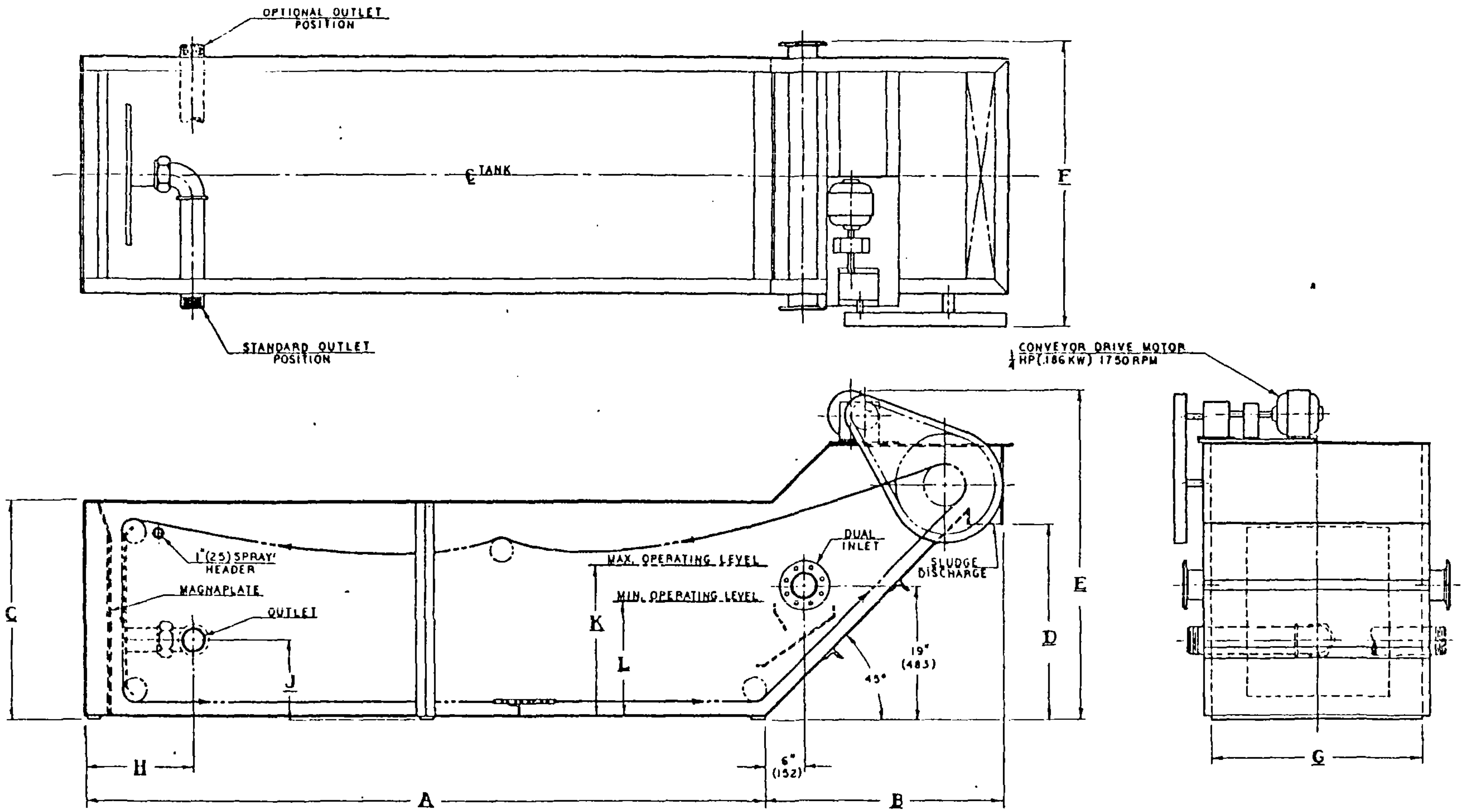

SECTION THROUGH MAGNAFLO SEPARATOR
AT INCOMING COOLANT DISTRIBUTOR

ILLUSTRATION 5-10




SECTION THROUGH MAGNAFLO SEPARATOR
AT COOLANT OUTLET END

ILLUSTRATION 5-11




| MODEL NUMBER | SIZE | DIMENSIONS IN INCHES | | | | | | | | | | | PIPE SIZES | | WT - LBS, TANK FILLED W/WATER | CAPACITIES IN GALLONS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | OPERATING LEVEL | | TOTAL TANK CAPACITY |
| | | A | B | C | D | E | F | G | H | J | K | L | INLET | OUTLET | | MAX. | MIN. | |
| 33073 | MF-40 | 48" | 28" | 25" | 22" | 40" | 41" | 30" | 15" | 11" | 21" | 16" | 3" | 2" | 2370 | 160 | 120 | 192 |
| 33074 | MF-60 | 6'-0" | 30" | 27" | 24" | 42" | 41" | 30" | 15" | 11" | 22" | 17" | 3" | 2½" | 3534 | 240 | 180 | 287 |
| 33075 | MF-80 | 6'-3" | 34" | 31" | 28" | 46" | 41" | 30" | 15" | 11" | 28" | 21" | 4" | 3" | 4344 | 320 | 240 | 350 |
| 33076 | MF-100 | 8'-0" | 34" | 31" | 28" | 46" | 41" | 30" | 15" | 11" | 28" | 21" | 4" | 3" | 3611 | 400 | 300 | 433 |

ILLUSTRATION 5-12

liquid which continues on through the compartment. The liquid on leaving the separator passes through an intense magnetic field which attracts magnetic particles from the liquid.

These separators are inexpensive to operate and maintain, fully automatic, self-cleaning while removing well over 90% of magnetic material. They deliver essentially a dry metallic product free of filter media and filter aids.

Operation

The contaminated coolant returning from the work area enters the settling compartment of the separator through a slotted distributor pipe. This distributor pipe has interior baffles which dissipates the incoming coolant velocity head while distributing the incoming coolant evenly across the precipitating area as shown in Illustration 5-10.

The coolant velocity drops drastically as it spreads out across the separator and moves through the precipitating area. The low velocity allows tramp oil and floating contaminants to rise to the surface of the coolant while heavy particles and sludge settles to the bottom of the separator to be caught and held for removal in the coolant non-moving boundary layer.

Extremely small particles of steel or cast iron which have not settled from the coolant continue on and pass around a vertical baffle at the outlet end of the separator. The coolant flow divides and passes around both sides and the bottom of the baffle and into and through two intense permanently maintained magnetic fields which attract and hold magnetic particles to a vertical magnaplate until the particles are moved to the bottom of the separator by slowly descending stainless steel flights as shown in Illustration 5-12. Here, the conveyorized flights carry particles and sediment along the bottom and up the sloping discharge end of the separator.

Sprays urge the floating contaminants and tramp oils towards the discharge end of the separator. As the sediment laden flights emerge from the coolant, they pick up the floating contaminants and continue moving slowly upwards toward the discharge point while all free coolant drains back into the separator. At the discharge point a virtually dry metallic sludge is dropped into a tote box for salvage.

5.6 CHROMIUM RECOVERY

As indicated by test data, the combined wastestream contains about 36 mg/l of chromium metal particles. Over the year at an average daily flow of 61,000 gallons per day about 4,700 pounds of chromium fines would be generated.

$36\ mg/l \times 15.8\ MGD \times 8.34 = 4743\ lbs$

The current price for Trans Vaal chromium ore is $48 to $52 per metric ton ($0.023/lb). This amounts to a value of $111 per year. The price for recovered chromium depends highly on an available market for the recovered chromium. A survey of metal reclaimers in the South Bend and Chicago area revealed a lack of a market for reclaimed chromium. A possible use for the chromium fines at Bremen Bearing might be to convert the raw chromium metal to chromic acid which is used in metal plating. The current selling price for high grade chomic acid flakes is about $109/100 lbs in 1000 lb lots.

Chromium oxides are used as the raw materials for the manufacture of certain metals and alloys. Sodium dichromate is used to make the chromium oxides by calcination of sodium dichromate ($Na_2Cr_2O_7$) with sulfur or carbon. Currently, sodium dichromate sells for about $67 for a 100 lb bag (McKesson Chemical Co., 40% chromium). Theoretically, if the chromium recovered from the Bremen Bearing wastestream could be converted to the basic sodim dichromate form, the 4700 pounds per year of chromium metal would yield about 6580 lbs of sodium dichromate having a value of about $44,000.

However, this full value would not be fully achievable due to the cost of converting the chromium metal to the dichromate form. The value would hinge upon finding a buyer or a chemical processor to buy the raw chromium fines and convert them to sodium dichromate. The buyer would pay considerably less than $6.70 per pound for the raw chromium. Further investigation of potential buyers for the chromium fines might prove advantageous.

The starting materials for the preparation of sodium dichromate are chromite ore, limestone and soda ash. When the above materials are reacted, sodium chromate is formed which is reacted with sulfuric acid to produce sodium dichromate. The reactions are given as:

$$4FeCr2O4 + 8Na2CO3 + 7O2 = 8Na2CrO4 + 2Fe2O3 + 8CO2 \quad (1)$$

$$2Na2CrO4 + H2SO4 = Na2Cr2O7 = H_2) + Na2SO4 \quad (2)$$

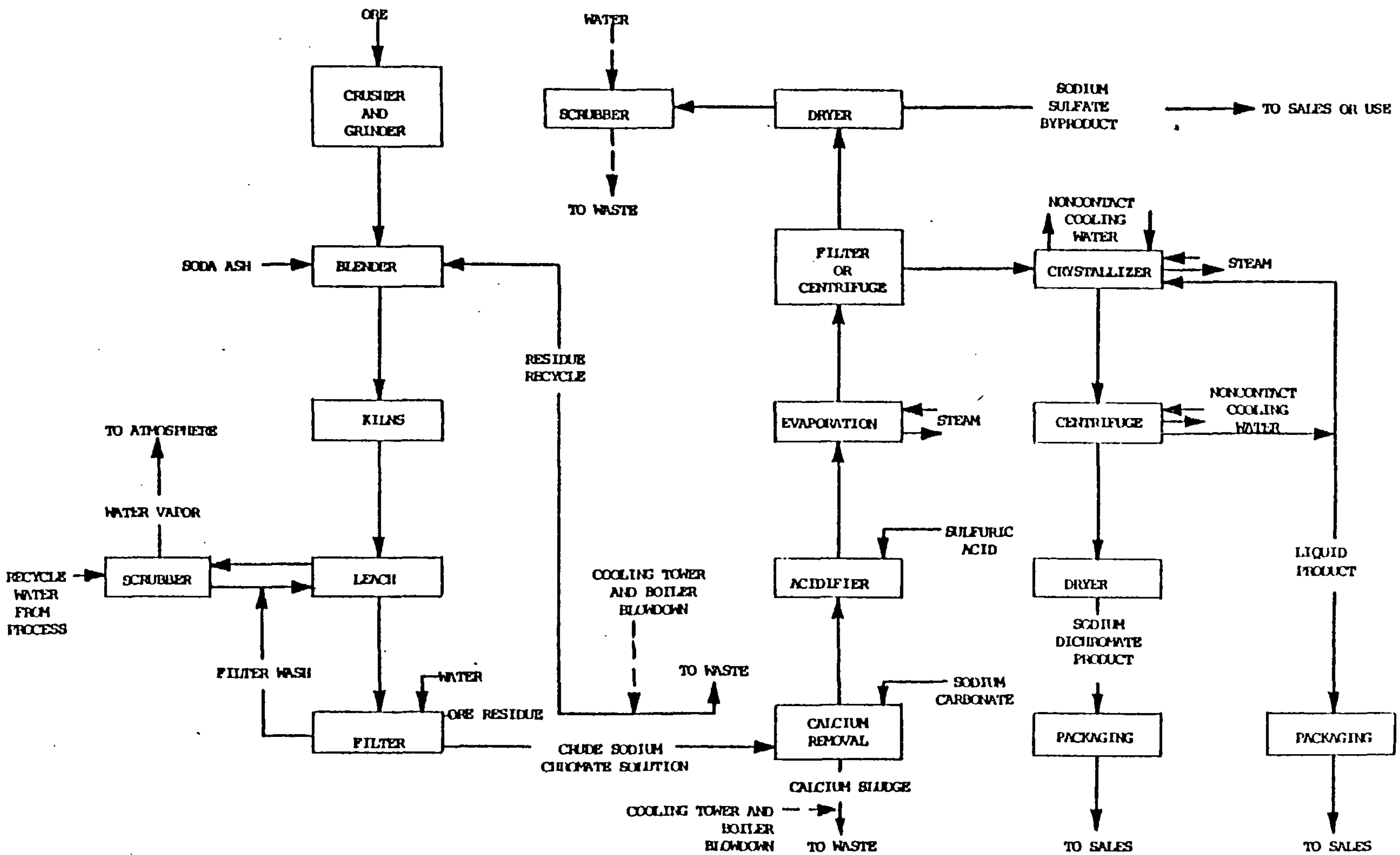
Chromite ore is a chromium iron oxide containing ferrous chromite (FeCr2O4 or FeOCr2O3). Small amounts of aluminum, silica and magnesia are present. For the preparation of sodium chromate and finally, sodium dichromate, high grade chromite ores are used containing approximately 50 percent Cr2O3. These ores are imported from South Africa.

At the plant site, the ore is ground to a fine powder, mixed with soda ash and calcined in rotary kilns at 1100 to 1150 degrees C.

The reacted product is leached with hot water in a leachate tank. The thickener underflow is filtered and the filtrate recycled to the leachate tank or thickener. The solid filter cake is dried in rotary kilns. The aluminum present in the thickener overflow is hydrolyzed and removed from the chromate solution as precipitated aluminum hydrate in slurry form. The solution is centrifuged and the centrate is evaporated, to give a concentrated solution of sodium chromate, which is reacted with sulfuric acid to give sodium dichromate and sodium sulfate. Sodium sulfate crystallizes as anhydrous sodium sulfate from the boiling solution, and the crystals are removed by filtration. The filtrate is concentrated in multiple effect evaporators. The residual sodium sulfates separate out as solids from each of the evaporators while the hot concentrated solution of sodium dichromate from the last effect of the evaporator is fed to a watercooled crystallizer. Sodium dichromate crystallizes cut and is centrifuged. The centrate, or mother liquor, is returned to the evaporator. The sodium dichromate crystals separated in the centrifuge are dried in a rotary drum dryer and then packaged for sale or stored for use. Illustration 5-13 presents a generalized flow diagram for the production of sodium dichromate.

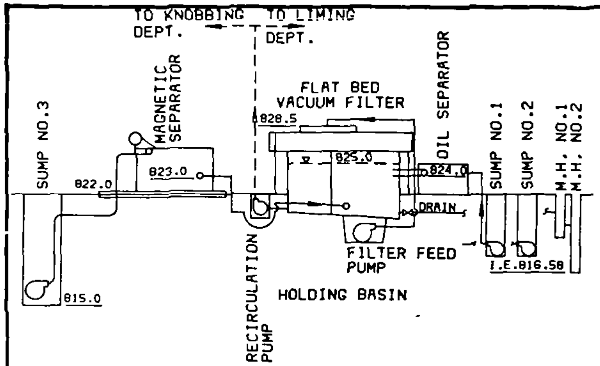
Technology does exist that could separate the chromium metal from the Bremen Bearing Wastestream. The dried metal fines from the filter and magnetic separator could be treated as an impure chromium ore and processed as above to yield sodium dichromate. Another method to extract usable chromium would be to use ion exchange units to remove chromate from acidified solution (pH = 2.0) of the wastestreams. Spent acid solutions containing chromium have been recovered for re-use by treatment with a polystryrene strong-acid cation exchange process. (Reference: Diamond Shamrock Chemical Company Duolite Ion-Exchange Manual 1969. Redwood City, CA) p. 147).

Further investigation into the feasible methods of chromium recovery using the above processes is beyond the scope of the present study. A detailed pilot study and market survey should provide the information needed to make a more definite determination about feasible recovery schemes and associated cost savings.

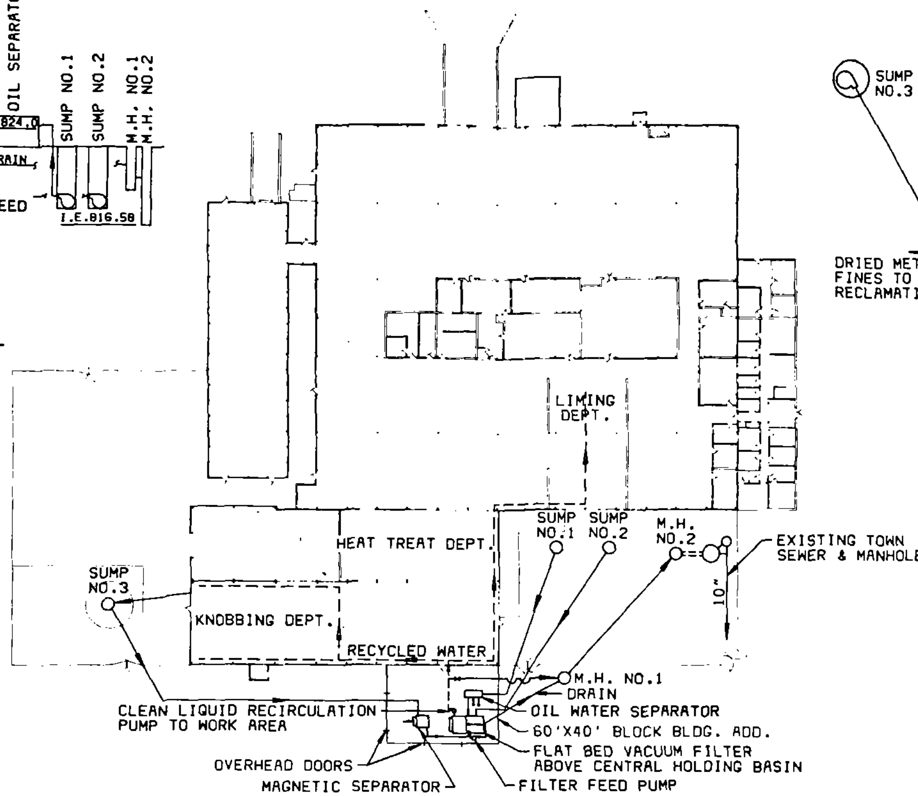


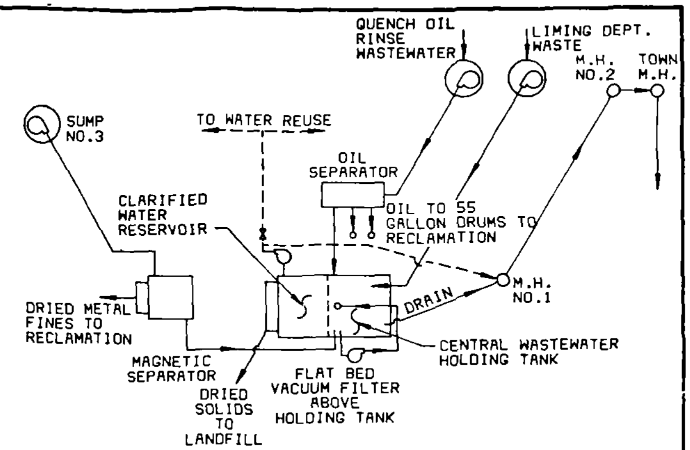

General process diagram for production of sodium dichromate.

ILLUSTRATION 5-13




HYDRAULIC PROFILE




FLOW SCHEMATIC

LEGEND

| | |
|---|---|
| - - - → | RECYCLED WATER |
| ——→ | PUMPED DISCHARGE |
| ——→ | WASTE GRAVITY FLOW |
| M.H. | MANHOLE |
| ⋈ | VALVE |

BREMEN BEARING PLANT LAYOUT

PLAN VIEW

APPROXIMATE SCALE: 1"=64'

CEWA
CLYDE E. WILLIAMS & ASSOCIATES, INC.
PROFESSIONAL ENGINEERS

PROPOSED TREATMENT SYSTEM LAYOUT, FLOW SCHEMATIC & HYDRAULIC PROFILE

BREMEN BEARING MASS FINISHING WASTES STUDY

ILLUSTRATION 6-1

values of the wastestreams, the toxic metals exist as solid precipitates such as hydroxides. These are removed along with the filter solid which are disposed at a landfill.

## 6.2 OPINION OF PROBABLE COSTS

The opinion of probable construction costs and project costs for the recommended treatment system are indicated in Table 6-1.

TABLE 6-1
OPINION OF PROBABLE COST

| Item | Cost |
|---|---|
| Sump No. 1 Duplex Pumps | $ 2,500 |
| Sump No. 1 Manhole | 1,000 |
| Sump No. 2 Duplex Pumps | 2,500 |
| Sump No. 2 Manhole | 1,000 |
| Sump No. 3 Duplex Pumps | 2,500 |
| Sump No. 3 Manhole | 1,000 |
| Oil/Water Separator (25 GPM) | 10,000 |
| Magnetic Separator (20 GPM) | 7,000 |
| Flat Bed Vacuum Filter (92 GPM) | 25,000 |
| Filter Feed Pump | 1,000 |
| Filter Piping | 1,500 |
| Water Recycle Piping | 2,500 |
| Water Recirculation Pump System Duplex Pumps | 1,500 |
| Building Addition (60' x 40') | 50,000 |
| Building HVAC | 10,000 |
| Manhole No. 1 | 1,000 |
| Manhole No. 2 | 1,000 |
| Outfall Sewer (8") | 500 |
| Force Main Piping | 1,500 |
| Equipment Connection Piping | 500 |
| Electrical Work | 3,000 |
| Pond Closure No. 1, No. 2, No. 3 | 8,000 |
| Contractor Mobilization & Supervision | 5,000 |
| Subtotals | $139,500 |
| Contingency Factor, 15% | 20,925 |
| TOTAL PROBABLE CONSTRUCTION COST | $160,425 |
| Final Engineering Design | 15,000 |
| Construction Guidance & Observation | 5,000 |
| TOTAL PROBABLE PROJECT COST | $180,425 |
| Present Worth of Power Costs ($4000/yr, 8%, 10 yr)* | 26,840 |
| Present Worth of O&M Costs ($9000/yr, 8%, 10 yr) | 60,390 |
| Present Worth of Recycled Water ($4600 per yr.; 8%, 10 yr) (50% Recycle at $0.58/1000 gal) | - 30,900 |
| Present Worth of Recovered Oil (750/yr, 8%, 10 yr) (5000 gal/yr @ $0.15/gal) | - 5,000 |
| Present Worth of Ferrous Recovery ($1650/yr, 8%, 10 yr) (82 tons @ $5-$20 per ton) | - 11,000 |
| Present Worth of Equipment Salvage Values | - 10,000 |
| TOTAL PRESENT WORTH OF PROJECT | $210,755 |
| EQUIVALENT ANNUAL WORTH OF PROJECT | $ 31,440 |

*Assumes a part-time employee to perform periodic maintenance on pumps and equipment. Sludge disposal costs are assumed to be the same as current solids disposal from the existing ponds.